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Carderock Division**

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**SMP95: Standard Ship Motion Program User Manual**

by

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The NAVY Standard Ship Motion Program (SMP) received a major revision in 1995 and later. The program code was upgraded to improve maintainability, portability and efficiency. Generality was improved by increasing the number of hull stations and points per station and the determination of wave frequency ranges. The roll damping predictions, active fins and rudders controller, added resistance predictions, and hull bending and shear loads calculations were substantially improved.

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The general input and output description is provided. Program operation is described. The detailed preparation of the program input record sets is presented.

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## **Abstract**

*The NAVY Standard Ship Motion Program (SMP) received a major revision in 1995 and later. The program code was upgraded to improve maintainability, portability and efficiency. Generality was improved by increasing the number of hull stations and points per station and the determination of wave frequency ranges. The roll damping predictions, active fins and rudders controller, added resistance predictions, and hull bending and shear loads calculations were substantially improved.*

*Seaway definition options were extended to include wave spectra for restricted waters. Absolute motions at a point can now be expressed in terms of motion sickness incidence and motion induced interruptions. Relative motions at a point may now include sinkage, trim and wave profile effects, with slamming expressed in terms of local pressure or force. Passive roll tank stabilizers can now be modeled.*

*The general input and output description is provided. Program operation is described. The detailed preparation of the program input record sets is presented.*

## **Administrative Information**

The work described in this report was performed by the Seakeeping Division (Code 5500) of the Hydromechanics Department at the Naval Surface Warfare Center, Carderock Division (NSWCCD). The report of this work was funded by the Naval Sea Systems Command as part of the Rapid Strategic Sealift Ship, Sealift NDSF R & D Program, work unit number 05-1-2123-404.

## **Introduction**

The NAVY Standard Ship Motion Program (SMP) [1]<sup>\*</sup>, [2] and [3] provides predictions of the motions, i.e., displacements, velocities, and accelerations, for a ship advancing at constant speed, with arbitrary heading in both regular waves and irregular seas. The irregular seas are modeled using a two-parameter Bretschneider wave spectral model. Both long-crested and short-crested results are provided. In addition to the six-degree-of-freedom responses, the absolute motion, velocity, acceleration, as well as the relative motion and velocity for various locations on the ship can also be obtained. The probabilities and frequencies of submergence, emergence, and/or slamming occurrence for various locations on the ship, are also available. Vertical shears and bending moments due to the ship motions can be produced.

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<sup>\*</sup> References are listed on page 65.



SMP was written in modular form to simplify future updating. The hull and appendage input, speed, heading, and sea condition calculation conditions, and statistical response output tables was all standardized. A new theory, associated with hull and appendage lift damping, was implemented for roll. Nonlinear predictions for roll in irregular seas are obtained using an iteration procedure. Finally, an interface with other programs required in the design process (performance assessment program, speed polar graphical program, and time history generation program) was provided by standard output files that can be saved by the user. Thus SMP need only be run once for a particular ship and the results saved on computer files for later use in other programs.

There have been three official documented versions of SMP: SMP81 [1], SMP84 [2], and SMP93-PC [3]. This report documents the last major revision to SMP that is designated SMP95.

## **Background**

Seakeeping prediction capabilities were developed over the years in a collection of computer programs. By 1977 it was recognized that there was a need for a user-oriented, state-of-the-art ship motion prediction tool that would be easy to use and maintain. This tool (SMP) would facilitate the incorporation of seakeeping considerations into the hull design at the earliest possible stage. In order to assure that this new tool would be of use to the design community, a planning committee comprised of members from NAVSEA and NSWCCD was formed to participate in the development of SMP.

This planning committee developed the input/output requirements, calculation procedures, and program structure for SMP. Most of the committee members were also involved in developing theory and providing source code changes for SMP. The planning committee developed a technical task breakdown for the construction of SMP. Each task was headed by a committee member who drew on laboratory and external contract sources in the development of the task.

The scope of SMP as originally planned would have included the capability to generate response time histories, as well as the capability to apply performance assessment criteria to the

irregular sea results. It became obvious during the development of SMP that the incorporation of these features would greatly increase computer time and unduly complicate the required input. The goal of having one program perform every conceivable calculation came into conflict with the separate goal of reducing the complexity of using such a tool. A compromise was achieved by restricting the scope of SMP81 [1] to that of providing basic ship motion predictions in irregular seas. The SMP84 [2] revision included some corrections and added active fins and vertical wave induced loads. The SMP93-PC [3] revision added wave frequency sets for small ships, estimates of ship axis lateral accelerations at a point, and transitioned the program to the personal computer. The organization of SMP93-PC and related programs is shown in Figure 1.

The SMP93-PC [3] version of the program provides the capability to obtain:

1. Rigid body motions: The rigid body responses include the displacements, velocities, and accelerations of the six-degree-of-freedom responses, surge, sway, heave, roll, pitch, and yaw.
2. Motions at a point: These responses include longitudinal, lateral, and vertical displacements, velocities, and accelerations for up to ten arbitrary points.
3. Relative motions and velocities at a point: These responses can be calculated for up to ten arbitrary points that can be different than the points used for the motions at point.
4. Probability and frequency of occurrence of slamming, emergence, and/or submergence at the points where relative motion is calculated.
5. Structural loads: Vertical shears and bending moments at up to ten stations defining the hull.

### **SMP95 Revision**

The objectives of the SMP95 development program that was begun in January of 1995 were to bring together the best of the developments to SMP since its introduction, to update the code as a solid basis for further development, and to improve and extend the prediction capabilities. The development program included a number of related tasks that were spelled out in the Task List of 10 November 1994. The resulting changes will be described next.

## **Upgrades for Maintainability, Portability and Efficiency**

Several upgrades were implemented to improve the maintainability, portability and efficiency of the SMP program code.

The program internals, particularly argument lists and common block contents, and the program structure were documented for much of the code. The code file was split into separate files for each subroutine and some oversize subroutines were split up. Common blocks were separated out and inserted in the subroutines with "Include" statements. Parameters were utilized in dimension statements to allow adjustments as needed. File assignments and disk input/output were reduced or eliminated when possible. Code porting between PC, VMS, UNIX, and other systems was made easier by collecting the few system dependent routines into one subroutine. The organization of SMP95 and related programs is shown in Figure 2.

## **Upgrades for Generality**

Several upgrades were implemented to improve the generality of SMP.

SMP95 now consists of two modules, SMPREGW, which carries out the regular wave hydromechanics computations, and SMPIRGW, which carries out the irregular sea motions computations. In the process, SMPIRGW has been made much more flexible than that part of the earlier versions of SMP. Previous versions of SMP combined the computations into one program, with SMP93-PC adding an option to stop or start the two parts of the program.

Speed selection was made more flexible. A list of up to eight individual speeds may be entered instead of the increment and maximum speed values.

The number of ship hull stations and the number of points on a station were increased from 25 and 10, respectively, to 70 for each. Knuckles or discontinuities in hull section input and longitudinal waterlines are now accommodated for the hydrostatic computations.

Wave frequencies selection for both the two-dimensional and three-dimensional added mass and damping calculations were improved from the previous fixed set of 10 frequencies. The 25 wave frequencies now range from 0.05 radians/second to a frequency corresponding to a wave length/ship length ratio of 0.05 at a Froude number of 0.40. The spacing of the frequencies

follows a geometric progression.

The wave frequencies selection for the response amplitude operators and wave components were improved from the previous four fixed sets of 30 frequencies. The 50 wave frequencies now range from 0.20 radians/second to a frequency corresponding to a wave length/ship length ratio of 0.05. The spacing of the frequencies follows a geometric progression that is centered about the calculated ship natural roll period.

### **Improvements to Existing Functionality**

The roll damping predictions, active fins and rudders controller, added resistance predictions, and hull bending and shear loads calculations were substantially improved.

The results of the major Japanese research project on improved roll damping that became available after development of SMP81 were evaluated but not incorporated. The effects of sonar domes, propeller shafting and propellers on roll damping have been incorporated. The sonar dome eddy damping is modeled as a short circular cylinder and the lift damping uses an estimated lift coefficient. The propeller shafts eddy damping is modeled as a long circular cylinder in cross flow and there is no lift damping. The propellers eddy damping is modeled using an estimated drag coefficient and the lift damping uses the propeller torque coefficients.

The active fins and rudders controller model was improved to represent adaptive controllers better and eliminate the previously required manual iteration in modeling active fin and rudder effects. The controller incorporates gain variations with speed, and allows limits on control surface angle and angular rate.

Previous versions of SMP included an added resistance calculation that considered the velocity potential of the hull motions interacting with the incoming waves that was evaluated using the Kochin function. Improvement of the added resistance calculation was attempted by incorporating the most recent Lin-Reed theory.<sup>†</sup> This theory added a waterline integral to the Kochin function evaluation. In addition to the incident wave potential, the wave diffraction potential action upon itself was incorporated. The evaluation of these potentials requires multiple

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<sup>†</sup> Reed, A. M., "The Second Order Steady Force and Moment on a Ship Moving in an Oblique Seaway-Revisited," unpublished manuscript, (1993).

evaluations of the Kochin function. The most recent Lin-Reed theory turned out to be a work in progress that could not be implemented with the available resources and the earlier version was retained with some necessary corrections. The diffraction potential was included in the Kochin function using a method developed by Newman [4].

$$\varphi_B = \sum_{j=1}^6 \alpha_j \varphi_j + \frac{i}{\omega} \left( \frac{\partial \varphi_0}{\partial y} \varphi_2 + \frac{\partial \varphi_0}{\partial z} \varphi_3 \right) \quad (1)$$

where  $\varphi$  is the velocity potential,  $\alpha$  is the motion amplitude response, and  $\omega$  is the encounter frequency.

The hull bending and shear loads calculations lacked the lateral plane components. The hull bending and shear loads calculations lacked the appendage and viscous loads, which resulted in the loads not going to zero at the ends of the ship as would be expected. After an analysis that is reported in Appendix A, the hydrodynamic end terms were deleted from the load calculations, the surge-pitch coupling term and part of the pitch restoring term were added to the vertical plane loads, and the appendage and viscous effects were included in the lateral plane loads.

### Extensions of Existing Functionality

Several upgrades were implemented to extend the functionality of SMP. Seaway definition options were extended to include wave spectra for restricted waters. Absolute motions at a point can now be expressed in terms of motion sickness incidence (MSI) and motion induced interruptions (MII). Relative motions at a point may now include sinkage, trim and wave profile effects, with slamming expressed in terms of local pressure or force. Passive roll tank stabilizers can also be modeled.

The seaway representation was extended to offer the options of using a modified version of the JONSWAP [5] [6] and the Ochi-Hubble six-parameter [7] wave spectra formulations. Both spectra can represent seas in restricted waters with a limited fetch, while the latter allows for combined seaway and swells. The maximum number of seaway significant wave heights was increased from 4 to 20, and up to 15 modal periods are now input by the user rather than using a set of 8 periods selected by the program.

The absolute motion calculations optionally include estimates of ship axis longitudinal accelerations that are in addition to the estimated ship axis lateral accelerations that were added in SMP93-PC [3].

The absolute motions calculations optionally include motion sickness incidence (MSI) using the prediction equations of McCauley and O'Hanlon [8]. The equations predict the percentage of unadapted subjects that become seasick in a given time interval for a given single acceleration frequency and amplitude. The prediction equation is solved using the root mean squared (rms) value of the vertical acceleration at the motion point location with the encounter modal period ( $T_{0E}$ ) of acceleration. These predicted MSI values were compared to those obtained using an ISO 2631 Part 3 1/3-octave band calculation method and to those recorded for subjects in the same motion simulator with irregular Sea State 5 conditions for FFG 7 [9]. The method used in SMP95 predicted a one-hour MSI value of 9%, the ISO 1/3-octave band method predicted a four-hour MSI value of 10%, and the motion simulator resulted in 16% to 32% one-hour MSI values. The conclusions were that the rms/  $T_{0E}$  method correlated as well with the motion simulator results and that the 1/3-octave band method was not worth the added effort.

The absolute motions calculations also optionally include motion-induced interruptions (MII) of ship operations due to the sliding and tipping of the crew members or equipment as a result of ship angles and accelerations [10]. The equations predict the number of times that the crew members are interrupted by ship motions in a given time interval.

The relative motion calculations incorporate sinkage and trim, and improved bow wave profile definition. The input of arbitrary sinkage and trim, and bow wave profile data as function of speed is now allowed. This allows the use of sinkage and trim data, and wave profiles from model tests, as calculated from potential flow calculations such as Beck, Newman, and Tuck [11], or as calculated from the new generation of steady forward motion panel codes. SMPREGW generates an input file Ship.bnt for the Beck, Newman, and Tuck program.

The Ochi-Motter [12] hull section shape and Stavovy-Chuang [13] truncated wedge slam pressure calculations and Schmitke [14] slam force calculations have been added to the slamming calculations. The Ochi-Motter method determines the hull section shape coefficient

from the hull offsets below the 0.1 waterline that is multiplied by the relative velocity squared to obtain the slam pressure. The default uses the shape coefficient for station 3 of the Mariner hull. The Stavovy-Chuang truncated wedge method calculates the section shape coefficient for a truncated wedge shape that is multiplied by the relative velocity squared to obtain the slam pressure. The Schmitke method integrates the slam pressures for several sections to give a total slam force value.

New passive stabilizer calculations that allow simulation of U-tube and free-surface tanks and moving weight stabilizers, have been incorporated into the regular wave module, SMPREGW. Estimates of the prevalence of stabilizer saturation are calculated in the irregular wave module, SMPIRGW. See Appendix B for a description of the passive stabilizer equations and input requirements.

The response amplitude operator (RAO) output was extended to provide ship response transfer functions for the wave frequencies or wave slope for comparison with model test results.

### **Program Assumptions**

The Standard Ship Motion Program (SMP) provides predictions of translational and angular ship statistical responses in irregular seas. These predictions are obtained from products of:

Ship Response Amplitude Operators (RAOs) x Sea Spectra x Frequency Mapping (2)

Predictions of ship responses in regular sinusoidal waves provide the database from which the RAO's are obtained.

Statistical ship motions in irregular seas, including short-crested seas represented by a cosine-squared distribution are calculated. The available sea spectrum models are a two-parameter Bretschneider spectrum, a three-parameter JONSWAP spectrum, and the six-parameter Ochi-Hubble spectrum. The parameters are wave height, modal period, and, for JONSWAP and Ochi-Hubble, peak amplitude factor.

SMP95 may only be run for displacement monohulls. Hull symmetry about the centerline is assumed. Appendages can be modeled including sonar domes, bilge keels, skegs, propellers

and shafts, struts, and rudders. Active anti-roll stabilization fins or rudders may also be used. There is also the capability to account for passive roll damping tanks. Either Metric or English units may be used, but the units may not be mixed.

## **Input and Output Schemes**

Of special note are the differences between the external input/output conventions (i.e., those apparent to the user) and those used internally in SMP. Specifically, the reference system and ship heading angle definition, perceived and utilized by the user, differ from those used for computations within the program.

The internal reference system has its origin located at the intersection of the longitudinal centerline of the waterplane section, with the transverse plane through the center of gravity. The user, however, references all input and output parameters to a point located on the longitudinal centerline, at the intersection of the forward perpendicular (Station 0) and the baseline (see Figure 3). This particular system was chosen to provide the user with a simple, consistent point of reference, one which is easily identifiable and one which does not vary with changes in ship draft or trim.

The internal heading convention for computational work within SMP is defined as 180 degrees for head seas, 90 degrees as starboard beam seas, and zero degrees as following seas (see Figure 4). The output tables and files (excluding data base files Ship.org, Ship.ltf, and Ship.ptf), however, treat 180 degrees as following seas, 90 degrees as starboard beam seas (unchanged), and zero degrees as head seas. This output heading convention was selected for consistency between program output and conventions employed by the ship and aircraft operator communities.

The differences between the internal and external input/output schemes are specified here, in order to avoid confusion. It is recognized that for the majority of users, the internal workings of SMP are, for the most part, inconsequential and can be ignored. Nevertheless, for those interested in altering, checking, or in some way manipulating the program, the distinctions between the reference and heading conventions are of importance in avoiding confusion.



## General Input Information

The main philosophy for the input design was to develop a basic, user-oriented format. To that end, emphasis was placed on two areas: reduction of program options and user-program control, and ease of describing the input parameters. The latter area is covered extensively in Record Set Description, and examples of the input are provided in Appendix C , Sample Input Files. The program options available in SMP and the program control that the user can exercise through the input, although also described in Record Set Description section, are of major importance and will be detailed further herein.

Through the input parameters, the user addresses the four major divisions of SMP: the input/hydrostatics, regular wave computations (in SMPREGW), irregular sea response statistics, and optional output (in SMPIRGW). The majority of the input to SMPREGW consists of the ship geometry description (including the hull form), appendages, active and passive roll stabilizers, and load condition (e.g., displacement, GM, etc.). In SMPIRGW point locations, other than the origin, define where motions will be computed. Points may also be selected for calculating kinematic relative motion<sup>†</sup> and the frequency of occurrence of slamming, submergence, and/or emergence at these locations, after the z-coordinates of the points are adjusted for sinkage and trim and wave profile. Irregular sea calculations are controlled by input of the sea states (significant wave heights) and specification of a statistic for the output tables and roll iteration.

For some input parameters specific program default values are described within each of the data record sets outlined in the Record Set Description section.

## General Program Output

SMP95 output can be divided into two types: (1) output data files that can be saved by the user after an SMP run, and (2) formatted plain text output files for hard copy printouts of the results of an SMP run. The former is described in more detail in Table 1, Program File Contents.

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<sup>†</sup> Kinematic relative motion is defined to be the difference between the absolute vertical ship motion (which includes heave, pitch, and roll components) and the undisturbed incident wave elevation at a point.

The latter, which is a function of user-selected options, will be summarized in this section. Selected examples of the program text output are provided in this manual in Appendix C .

No matter which options are selected in SMPREGW, three standard sections of output will be created. The sections are: an input record echo, an input record description, and tables of ship and appendage particulars. The input record echo is a listing of the input records, exactly as the program reads them. The input record echo provides the user with a permanent record of the file. The input record description follows the input echo and identifies the individual input parameters per data record set. This is useful for debugging purposes. The table of ship particulars presents the dimensional and nondimensional characteristics of the ship's hull and loading configuration. Hydrostatic calculations of displacement, metacentric height (GM), longitudinal center of gravity (LCG), and calculated roll period are helpful in checking the input.

One other type of optional output available to the user contains some of the coefficients of the equations of motion. Selection of the roll damping print option (RLDMPR= 1, Data Record Set 2) will generate a table of zero speed nondimensional added mass and damping coefficients, as well as tables of nondimensional roll decay coefficients for the fully-appended hull.

The primary output of SMPIRGW consists of tables of ship responses in irregular seas. The irregular seas are modeled using a two-parameter Bretschneider sea spectrum, with significant wave height and modal wave period input by the user. Alternatively, limited-fetch, non-fully developed, irregular seas are modeled by the JONSWAP spectrum, which is a Bretschneider spectrum multiplied by a frequency dependent factor. In addition to the significant wave height and modal period input, the user is to input an additional parameter that scales the spectral peak. Alternatively, the Ochi-Hubble six parameter spectrum requires the input of two sets of wave height, modal period, and peak factor for the shorter and longer period components of the seaway. Separate output tables are optionally provided for both the long-crested and short-crested descriptions of the seas.

The ship responses are presented in the form of single amplitude Response Statistical Values (RSV) and periods of maximum energy in the response encounter spectra ( $T_{0E}$ ). The basic table format is comprised of RSV/ $T_{0E}$  values for a single ship response, at a particular

location, and for a particular significant wave height.

Each table contains predictions for all speeds; for headings from zero through 180 degrees for symmetric responses and zero through 360 degrees for asymmetric responses; and for a range of modal wave periods.

The statistic used in the tables is specified by the user (see SMP1rgw Record Set 3). This statistic is derived from a Rayleigh distribution and is applied to all responses. Roll predictions are non-linear by roll angle and thus sea state. A set of eight trial roll angles is calculated using the roll damping values that are predicted for a default set of eight assumed roll angles. Some of the trial roll angle will be less than the roll angle assumed for the damping and some more. The resulting roll angles are interpolated to match the assumed roll angle for the damping with the calculated roll angle. Other nonlinear responses (those that involve sway, roll, or yaw components) are obtained through interpolation using the irregular sea roll predictions.

The ship responses will not be output by default. However, output options (Data Record Set 7) allow the user to obtain the displacements, velocities and accelerations. In addition, if the user specifies absolute motion locations (Data Record Set 5), tables of the displacements, velocities and accelerations in earth and body axis, as well as motion sickness and motion-induced interruptions, may be printed. Additionally, if the user specifies relative motion locations (Data Record Set 6), tables of relative motion, relative velocity, and then the probabilities of slamming, submergence, or emergence, are optionally provided. In this last case, the pairs of numbers in the tables are probabilities  $\times 100/\text{number of occurrences per hour}$  rather than  $RSV/T_{0E}$  values. Alternatively, slam pressures or forces are optionally provided in pairs of pressure or force/number of occurrences per hour. In addition, optional output of a user defined severe motion table is available. The final output option is the output of the shear forces, torsional moment, and bending moments.

It should be pointed out that the user has the ability to generate a massive amount of output. To illustrate this point, if the user were to select the velocity/acceleration print option and were to specify only one point location (not on the centerline) for four significant wave heights (default), a total of 264 pages will be output. For each additional point location, 120 more pages

will be generated. Furthermore, for the number of speeds exceeding five, the user should double these figures. Obviously, a thorough survey by the user as to what his needs are in the way of hard copy output will result in a more efficient, cost-effective run of SMP.

Besides the velocity and acceleration print option, an additional print option is provided for the user. However, in view of the great amount of data that is printed by default, caution is encouraged in its use. Selection of the RAO print option (RAOPR=1 or 2, Data Record Set 2) will generate tables of Response Amplitude Operators (RAO) and their associated phase angles for the six-degree-of-freedom responses at the origin location, surge, sway, heave, roll, pitch, and yaw.

One RAO table is provided for each speed, heading, and sea state. The sea states are obtained using the input significant wave heights (Data Record Set 4) and appropriate modal periods selected from the default modal periods used for the RSV/T<sub>0E</sub> tables. The vertical mode response RAOs (surge, heave, and pitch) are linear and are independent of sea state. The lateral response RAOs (sway, roll, and yaw) are nonlinear and vary with sea state. The lateral RAOs are obtained by interpolation, using the roll RSV value computed for the particular speed, heading, significant wave height, and modal period. It should be noted that the roll RSV value also depends on the Rayleigh statistic specified in the input (Data Record Set 4). Also RAO tables are provided for only the first sea state in head or following waves, where sway, roll, and yaw are zero. The total number of RAO tables output is,

$$\text{Number of speeds} \times (2 + 11 \times \text{number of sea states}) \quad (3)$$

Thus, for five speeds and two sea states, there would be a total of 120 pages. Because of the amount of output obtained from the RSV/T<sub>0E</sub> tables, it is advised that the RAO/phase data be printed only when absolutely necessary.

The user may wonder what alternative there is to obtaining a vast amount of computer output. One solution may be to obtain the minimum output required and to save the origin (ORGFIL) file that is produced by SMPREGW. Further output can then be obtained at a later date by running SMPIRGW again. Response statistical (RSV) tables and Response Amplitude Operator (RAO) tables for new sea states (Data Record Set 4) can be obtained in this fashion.

Another solution lies in the Polar Plot (SPDFIL), Speed Polar (SPLFIL) and Slam Polar (SLMFIL) files. These files contain the same statistical information that is output in the tables. Furthermore, the files contain the velocity/acceleration statistics, even though the user may not have selected the VLACPR option. Manipulation of these files, whether by selectively plotting responses of interest using the POLARPLOT [15] program for SPDFIL or the VISUALSMP [16] program for SPLFIL and SLMFIL, or by sorting through the data using some user-supplied auxiliary program, allows the user to reduce hard copy output, while still acquiring the desired information.

### **Range of Validation**

SMP95 provides a potential flow solution based on linearized strip theory. The assumptions inherent in this theory are that ship length is large compared to beam and draft, and that hull section and waterplane properties are represented by the calm water values. The latter condition requires that ship motions be limited to small amplitudes. Accuracy will be reduced for ships with low length-to-beam ratios (less than 5) where end effects are significant, and for large amplitude motions (wave heights in excess of the draft) where non-linear effects are significant.

Generally, pitch and heave motions computed by SMP are more accurate than roll [17]. Despite the implementation of non-linear roll damping, the peak value of the roll transfer function can be inaccurate as roll is a lightly damped, narrow-banded motion and is consequently very sensitive to estimated roll damping [18]. Roll motions are also sensitive to roll moment of inertia. The roll damping semi-empirical relations do not allow predictions for bilge radii of less than 3 feet. The roll damping effects due to hard chines can only be approximately modeled by appendages. The validation studies were done with SMP81 and were not repeated for SMP95.

### **Program Operation**

#### **Starting the Program**

The program is started under Windows by running the RunSMP95.pif, RunREGW.pif, or RunIRGW.pif file. The RunSMP95 program information file (pif) runs a DOS batch file

RunSMP95.bat that requests the input 'Ship' file names and then executes the SMPREGW and SMPIRGW programs. 'Ship' stands for the name of the input files that are supplied by the program user, without the extension ".ext". The input file, 'Ship'.INP for SMPREGW and 'Ship'.IRG for SMPIRGW, is assumed to be located in the current directory. The output files are assigned the file name of 'Ship'.ext and saved in the same directory. The batch files will note an error if the required input files are not available and stop. A diagram of this process is shown in Figure 2.

The RunREGW.pif file runs a DOS batch file RunREGW.bat that executes SMPREGW and RunIRGW.pif file runs a DOS batch file RunIRGW.bat that executes SMPIRGW individually. The RunIRGW.pif run must be preceded by a RunREGW.pif or RunSMP95.pif run using the same input 'Ship' file name.

The program can also be invoked using the example com and shell script files that are in subroutine SysDep.For for the Digital VMS and UNIX operating systems. The UNIX shell script will probably need modifications to work with the LINUX operating system.

The SMP95 program is a batch program that requires no user interaction after starting the pif file. The remainder of the manual describes the detailed format of the input file.

## **SMP Input Record Overview**

The input to be developed for SMP consists of hull form data, loading data, appendage data, point location data, and environmental data. The actual input of this data into SMP is accomplished via an ASCII text file that is made up of data record sets. The number of data record sets required for SMPREGW is 18 and for SMPIRGW is 8; however, the number of records within each set will vary according to the individual ship particulars and user requirements. Table 2 summarizes the data record sets. Comments, which are indicated by a # in column 1, may be inserted between data record sets and within sets except when repeated data records are input.

Users should be aware that when using fixed input file formats, it is emphasized that integers must be keyed at the correct location, i.e., right-justified within their specified fields.

Floating point (real) numbers should also be right-justified within their specified fields. Character information should be left-justified within the specified fields (unless otherwise indicated in the data record sets).

The reference system that is used for input data to SMP is illustrated in Figure 3. The origin for this system is defined as the intersection of the ship's forward perpendicular (FP), centerline, and baseline. The x-coordinate of this system is measured in station numbers with Station 0.0 defined at the forward perpendicular and Station 20.0 defined at the aft perpendicular. The y-coordinate of this system is measured from the ship's centerline with y positive to port. The z-coordinate of this system is measured from the ship's baseline with z positive up. The units of y and z must be the same, but can be expressed in either feet or meters. This reference system is used to define the input values for the under-water hull geometry, hull and loading particulars, appendage information, and point locations where motions are computed.

### **SMPREGW Record Set Description**

This particular section on the description of the record sets is an illustrative formulation on how to prepare an SMP SMPREGW input file. It is an important section to which the user should constantly refer before running a ship through SMP. Thus, careful reading of this section is highly recommended.

Note that each data record set is made up of one or more records. Any specific data record set that should not be used is represented by a blank record. It should also be noted that some records within a data record set may be eliminated or omitted, depending on the user's needs and information. The method used to describe each data record set is to list each record, its FORTRAN format, and the variable(s) contained in it.

#### ***Record Set 1: Title***

Record 1 - FORMAT (20A4) – always required.

[TITLE] (Character) - columns 1-80, title information.

This is a one-record data set consisting of up to 80 characters. The title should be centered

on the record and usually includes the ship, date, project, and/or other parameters that make this run unique. This information will be output at the top of each printed page. For historical reference, the user may desire to cite the ship's draft, trim and metacentric height on this title record.

### ***Record Set 2: Program Options***

This is a one-record data set that enables the user to control the extent of program execution and the amount of data output. Nine option variables are contained on this record set.

The first variable, OPTN, is the program run option. The amount of calculations and thus the run time is controlled by this option. Previous versions of SMP had six possible selections for OPTN that have now been reduced to two in SMPREGW. The next two option variables, VLACPR and RAOPR, as well as LRAOPR, were used in SMP93-PC to control the irregular wave output. The two option variables, RLDMPR and ADRPR select specific output tables to be printed. The next variable, ORGOPTN, was used in SMP93-PC to stop or start the program at the end of the regular wave calculations. The next variable, VGOPTN, causes the hull offsets to be moved to locations designated by the sinkage and trim input. The last variable, RDMSEL, has not been implemented.

Record 2 - FORMAT (9I5) – always required.

[OPTN] (Integer) - column 5, program control option.

1 - Hydrostatic calculations only. The output (PRNFIL) consists of an input record "echo," an input record description, and tables of ship and appendage particulars. A Ship Hull Offsets file (HPLFIL) is written containing spline-fitted hull lines, in addition to the input offsets. This file can be used for off-line plotting. This is a quick running option taking a few seconds to check the input file.

2 - Full run of SMPREGW for all motions. The output (PRNFIL) is the same as for OPTN=1. The following files are written: Ship Hull Offsets file (HPLFIL), Origin Transfer Function file (ORGFIL). This option takes a minute or two to run.

If no value is selected for OPTN (i.e., OPTN=0), a full run of SMPREGW is made as in



OPTN=2.

[VLACPR] (Integer) - column 10, velocity and acceleration print option that was moved to Record Set 2 of SMPIRGW.

0 or blank

[RAOPR] (Integer) - column 15, Response Amplitude Operator (RAO) print option that was moved to Record Set 2 of SMPIRGW.

0 or blank

[RLDMPR] (Integer) - column [19] 20, roll damping print option. This output is not extensive.

0 or blank - No roll damping tables printed.

[-] 1 - Output roll damping tables for the fully appended ship. A table of nondimensional zero speed added mass and damping is printed.

[-] 2 - same as above plus damping and percent of total damping, for each appendage, by device (hull, bilge keel, etc).

[-] 3 - same as above plus damping and percent of total damping by physical mechanism (skin friction, eddymaking, wave making, lift, etc).

If  $RLDMPR > 0$ , then roll decay value "n" is printed out. If  $RLDMPR < 0$ , then nondimensional  $B_{44}$  is printed. The latter is also labeled "n", although strictly speaking it is not.

[LRAOPR] (Integer) - column 25, load RAO print option that was moved to Record Set 2 of SMPIRGW.

0 or blank

[ADRPR] (Integer) - column 30, added resistance calculation and print option. The SMPIRGW RSV output will add a page of added resistance force values for each sea condition when this option is selected. If  $RAOPRNOPTN > 0$  in SMPIRGW Record Set 2, tables of added

resistance operators are printed out after the RAO tables.

0 or blank - No added resistance force calculations or output.

1 - Calculate the added resistance force for output in the SMPIRGW RSV/ $T_{0E}$  tables.

[ORGOPTN] (Integer) - column 35, origin transfer function file start and stop option. This option in SMP93-PC allowed the program to be stopped after generating the origin transfer function file or the program to be started using the origin file to get the irregular wave output. The split of SMP95 into SMPREGW and SMPIRGW has the same effect and this input is ignored.

0 or blank - Normal SMPREGW run.

[VGOPTN] (Integer) - column 40, variable geometry option. The offsets for each station defined in Record Set 6 are moved vertically according to the sinkage and trim values that are defined in Record Set 16 as a function of ship speed.

0 or blank - Existing SMP option (no geometry variation).

1 - allow geometry variation for sinkage and trim.

This requires STOPTN (Record Set 16) not equal 0 and also affects offset input (Record Set 6).

The variable geometry option combined with trim results in the hull being distorted as the sections are simply moved vertically. Consequently, the results will be best if the trim is relatively small. Also, with the variable geometry option, segments are generated as specified; the geometry input is separated from the segmentation specification. A rectangular section, for example, requires only three input points, even if finely segmented. Sections may enter or leave the water. It will work for "normal" monohulls, but unusual shapes may result in difficulty. The resulting immersed form must be a monohull. Sections must be simply connected; a hull with a large protruding bulb and a large protruding above water bow will fail.

[RDMSEL] (Integer) - column 45, roll damping model selection option. For future development only, no input is currently read in Record set 18.

0 or blank - No selection.

### ***Record Set 3: Physical Units***

Record 3 - FORMAT (2A4,2X,2F10.4,F10.8) – always required.

[PUNITS] (Character) - columns 1-8, allowable physical units, e.g., units of length: FEET or METER. If METER does not appear in columns 1-5, SMP will default to FEET. All dimensional input and output is assumed to be in the selected system of units, as noted below.

[RHO] (Real) - columns 11-20, mass density of water in PUNITS. For example, if PUNITS=FEET, use a value of 1.9905 slugs/ft; or, if PUNITS=METER, use a value of 1025.82 kg/m<sup>3</sup> for salt water.

[GRAV] (Real) - columns 21-30, acceleration of gravity in PUNITS. For example, if PUNITS=FEET, use a value of 32.1725 ft/sec<sup>2</sup>; or, if PUNITS=METER, use a value of 9.8062 m/sec<sup>2</sup>.

[GNU] (Real) - columns 31-40, kinematic viscosity in PUNITS. For example, if PUNITS=FEET, use a value of 0.00001279 ft<sup>2</sup>/sec; or, if PUNITS=METER, use a value of 0.00000119 m<sup>2</sup>/sec. These values are based on salt water at one atmosphere, 15<sup>0</sup> C (59<sup>0</sup> F).

These values determine the physical constants used in the calculation of the pressures and motions. The suggested magnitudes of these units were taken directly from the ITTC tables. PUNITS has two allowable options (FEET and METER) that enable the user to specify whether English or Metric units will be used for all of the input data and output results.

### ***Record Set 4: Hull Particulars***

Record 4A - FORMAT (3F10.4,F10.2,3F10.4) – always required.

[LPP] (Real) - columns 1-10, length between perpendiculars in PUNITS.

[BEAM] (Real) - columns 11-20, beam at Station 10 in PUNITS.

[DRAFT] (Real) - columns 21-30, draft at amidships in PUNITS.

[DSPLMT] (Real) - columns 31-40, displacement in long tons (salt water) if

PUNITS=FEET or mass in metric tons if PUNITS=METER.

[VKDES] (Real) - columns 41-50, design speed in knots. The design speed, in conjunction with the next variable, VKINC, is used in determining the total number of speeds and the maximum speed for which motions are computed. For example, for VKINC=5 (default), the ship speeds used in the computations are: 0, 5, 10, . . . , VKDES. In this case, if VKDES is not divisible by 5, the next higher speed divisible by 5 is used as the maximum speed. If VKDES is less than 0.0, then records 4B and 4C below are read.

[VKINC] (Real) - columns 51-60, increment for speed. If VKINC is zero or blank, a default value of 5 is assigned.

[AMODL] (Real) - columns 61-70, model length. Used for Reynolds number scaling in skin friction and bilge keel calculations when model results are desired (RHO and GNU are to be changed to fresh water values). Set AMODL to zero for full-scale calculations.

The hull particulars are in PUNITS units and are printed in the hydrostatics output. The displacement printed in the hydrostatic table is calculated from the hull geometry and should be checked with the input value to see if it is within tolerance. The maximum number of speeds used in the computations is 8; therefore  $(VKDES/VKINC)+1$  should always be  $\leq 8$ . Zero knots is always the first speed.

If VKDES is less than 0.0, then the following records 4B and 4C are read, otherwise omit.

Record 4B - FORMAT (I5)

[NVK] (Integer) - columns 1-5, number of ship speed values, maximum of 8.

Record 4C - FORMAT (8F10.4)

[VK(I)] (Real) - columns 1-10, 11-20, . . . , 71-80, ship speeds in knots in ascending order.

In this case, an arbitrary array of speeds is read in, VKDES is further ignored and VKINC is completely ignored. The speeds must be in ascending order, otherwise spline interpolations over speed will fail.

### ***Record Set 5: Loading Particulars***

Record 5 - FORMAT (6F10.4) – always required.

[GMNOM] (Real) - columns 1 -10, nominal value of metacentric height GM in PUNITS, which should include any free surface corrections. The actual value of GM used in SMP is computed as part of the hydrostatic calculations. GMNOM is provided as a check for the user on the calculated GM value. GMNOM must always be  $> 0$ .

[DELGM] (Real) - columns 11-20, free surface correction, if any, in PUNITS. Always positive and included in GMNOM, DELGM does not affect the location of the metacenter (KM).

[KG] (Real) - columns 21-30, distance from the keel to the center of gravity at the LCB in PUNITS. The KG value that is input corresponds to the uncorrected GM. The KG value printed in the hydrostatic table includes any free surface correction (KG+DELGM).

[KPITCH] (Real) - columns 31-40, pitch radius of gyration divided by LPP. A typical value of KPITCH is 0.25.

[KROLL](Real) - columns 41-50, roll radius of gyration divided by BEAM. KROLL is referenced to the vertical center of gravity. A typical value of KROLL is 0.35 to 0.43.

[KYAW] (Real) - columns 51-60, yaw radius of gyration divided by LPP. A typical value of KYAW is 0.25.

### ***Record Set 6: Hull Geometry and Weight Distribution***

The underwater part of the hull is described in this record set by stations in the x direction and by station offsets in the y and z directions using the Input Reference System shown in Figure 5.

An important consideration in preparing the offsets is to include the skeg(s) when describing the aft hull lines. In addition to perhaps losing a significant amount of displaced volume, elimination of the skeg(s) from the hull description alters the computation of roll damping due to hull shape. A separate input description of the skeg(s) as an appendage will also be required in Record Set 10 to determine lift and eddy damping.

Record 6A - FORMAT (4I5) – always required.

[NSTATN] (Integer) - columns 4-5, number of stations (maximum of 70). Note that if VGOPTN = 1 (Record Set 2, variable geometry option) the maximum number of input stations allowed is reduced by 2 from the maximum number of 70 (MXNSTATN as listed in the output).

[NLOADS] (Integer) - columns 9-10, number of stations where wave induced loads are to be calculated (maximum of 10). No loads are to be calculated if NLOADS=0. If NLOADS is greater than zero, two additional record sets 6H and 6I must be provided at the end of the hull offset input.

[NBB] (Integer) - columns 14-15, bow bulb indicator. This is moved from another Record set in the earlier versions of SMP, and is used only by the Bishop and Bales approximations for sinkage, trim, and wave profile, which lack an option for smaller powering bow bulbs.

0 - No bow bulb.

1 - Large destroyer-type sonar dome bow bulb.

[LKNPF] (Integer) – columns 19-20, longitudinal knuckle or discontinuity indicator.

0 - No longitudinal knuckles.

1 - Logitudinal knuckle flag read at each station.

Record Set 6B – FORMAT(2I5) - required only if VGOPTN = 1, omit if VGOPTN = 0.

[NBP] - columns 4-5, number of points for bow profile. The maximum number of points on the bow profile is equal to the maximum number of points on a station (without the reduction for VGOPTN = 1 noted below.)

[KNFBP] - column 10, bow profile knuckle or discontinuity indicator. If KNFBP is 1, then an additional record in this set is read below.

0 - No knuckles on bow profile.

1 - Read array of knuckle flags.

Record - FORMAT(10X,10F7.2) – required only if NBP is greater than 0, omit if NBP=0.

[BPST(J)] – columns 11-17, 18-24, . . . , J=1,NBP, stations of points on the bow profile.  
The input is similar to that shown in Figure 5.

Record - FORMAT(10X,10F7.2) – required only if NBP is greater than 0, omit if NBP=0.

[BPWL(J)] – columns 11-17, 18-24, . . . , J=1,NBP, waterlines of points on the bow profile, going from the keel to the deck, repeated for as many lines as required. The waterline values should extend at least 3 feet (1 meter) above the highest waterline that will be used to allow for the effects of sinkage and trim as specified in Record Set 16.

Record - FORMAT(10X,10(6X,I1)) - required only if KNFBP equals 1, omit if 0.

[KNPBP(J)] - columns 17, 24, . . . , J=1,NBP), bow profile knuckle or discontinuity flag, repeated for as many lines as required.

0 - No bow profile knuckle at this point.

1 - Bow profile knuckle at this point.

NEXT RECORDS 6C – 6F ARE REPEATED FOR K = 1, NSTATN STATIONS.

Record 6C - FORMAT (F10.4,4I5) – always required.

[STATN(K)] (Real) -columns 1-10, station number.

The stations are input in the order they occur along the ship, starting from the forward most underwater station and ending at the aft most underwater station. Stations forward of the FP and aft of the AP are allowed. For example, -0.28, 0.25, 0.5, 1.0, 2.0, . . . , 10.0, . . . , 19.0, 20.0, 20.5. Station 10 must always be included.

[NSOFST(K)] (Integer) - columns 14-15, number of station offsets (maximum of 70).  
NSOFST is variable from station to station, with a value of 0 allowed if there are no offsets at a particular station (usually the FP and AP). The minimum value of NSOFST is 3 for stations with offsets. The FP and AP stations with NSOFST=0 are included for longitudinal integrations.

[KNPF(K)] (Integer) - column 20, section knuckle or discontinuity indicator. If KNPF is 1, then an additional record in this set is read below.

0 - No section knuckles at this station.

1 - Section knuckles at this station.

[NPTOS(K)] (Integer) – columns 24-25, if VGOPTN = 1, the number of offset points to be used in the calculation. This allows calculations to be made at lower drafts, which are included in the station offsets, than the top offset.

Note that if VGOPTN = 1 the maximum number of offsets per station allowed is reduced by 1. The maximum value of NPTOS is not reduced in this case, however. If VGOPTN = 1, stations with 0 points (as at the ends of the hulls) are not allowed. The bow and stern profile options Records 6B and 6G are used for this purpose with variable geometry.

[LKNP(K)] (Integer) – column 30, longitudinal knuckle or discontinuity flag.

0 - No longitudinal knuckle at this section.

1 - Longitudinal knuckle at this section.

Record 6D - FORMAT (F10.4,10F7.2,6(10X,10F7.2)) – always required. In the case of NSOFST=0, Record 6D must still be included.

[STATN(K)] (Real) - columns 1-10, station number.

[HLFBTH(I, K)] (Real) - columns 11-17, 18-24, . . . , [(NSOFST-1)\*7+11] - [NSOFST\*7+10], station y-coordinates in PUNITS for NSOFST(K) offsets (referenced to the centerline, always positive), repeated for as many lines as required.

Record 6E - FORMAT (F10.4,10F7.2,6(10X,10F7.2)) – always required. In the case of NSOFST=0, Records 6E must still be included. The input is entered as shown in Figure 5.

[STATN] (Real) - columns 1-10, station number.

[WTRLNE(I, K)] (Real) - columns 11-17, 18-24, . . . , [(NSOFST-1)\*7+11] - [NSOFST\*7+10], station z-coordinates for NSOFST(K) offsets (referenced to the baseline, positive up), repeated for as many lines as required. If the variable geometry option (VGOPTN = 1) is selected, the waterline values should extend at least 3 feet (1 meter) above the highest waterline that will be used to allow for the effects of sinkage and trim as specified in Record Set 16.



Record 6F - FORMAT(10X,10(6X,I1)) - required only if KNPF(K) equals 1, omit if 0.

[KNP(I, K)] - columns 17, 24, . . ., J=1, NSOFST), section offset knuckle or discontinuity flag for NSOFST(K) offsets, repeated for as many lines as required.

0 - No section offset knuckle at this point.

1 - Section offset knuckle at this point.

Record Set 6G - FORMAT(2I5) - required only if VGOPTN equals 1, omit if 0.

[NSP] - columns 4-5, number of points for stern profile. The maximum number of points on the stern profile is equal to the maximum number of points on a station (without the reduction for VGOPTN = 1 noted above.)

[KNFSP] - columns 9-10, stern profile knuckle or discontinuity indicator. If KNFSP is 1, then an additional record in this set is read below.

0 - No knuckles on stern profile.

1 - Read array of knuckle flags.

Record - FORMAT(10X,10F7.2) - required only if NSP is greater than 0, omit if 0.

[SPST(J)] - columns 11-17, 18-24, . . ., J=1,NBP, stations of points on the stern profile. The input is similar to that shown in Figure 5.

Record - FORMAT(10X,10F7.2) - required only if NSP is greater than 0, omit if 0.

[SPWL(J)] - columns 11-17, 18-24, . . ., J=1,NBP, waterlines of points on the stern profile, going from the keel to the deck, repeated for as many lines as required. The waterline values should extend at least 3 feet (1 meter) above the highest waterline that will be used to allow for the effects of sinkage and trim as specified in Record Set 16.

Record - FORMAT(10X,10(6X,I1)) - required only if KNFSP equals 1, omit if 0.

[KNPSP(J)] - columns 17, 24, . . ., J=1,NBP), stern profile knuckle or discontinuity flag, repeated for as many lines as required.

0 - No stern profile knuckle at this point.

1 - Stern profile knuckle at this point.

NEXT RECORD 6H IS REPEATED FOR  $K = 1$ , NSTATN STATIONS, IF NLOADS > 0.

Record 6H - FORMAT (6F10.4) - required only if NLOADS is greater than 0, the following record is repeated NSTATN times to define the ship weight distribution, omit if 0.

[STATN(K)] - columns 1-10, station number. Stations for this section of input must be exactly the same stations as for the definition of the hull offsets.

[SWGHT(K)] - columns 11-20, a lumped weight which represents an apportionment of the weight curve to STATN(K). Note that weight is expected to be in long tons (force) if PUNITS="FEET", or metric tons (mass unit) if PUNITS="METER".

[SKG(K)] - columns 21-30, vertical location of the center of gravity of the weight apportioned to the station, in PUNITS, positive above baseline.

[SKROLL(K)] - columns 31-40, the roll gyradius of the weight apportioned to the station, in PUNITS.

[SKPITCH(K)] - columns 41-50, the pitch gyradius of the weight apportioned to the station, in PUNITS.

[SKYAW(K)] - columns 51-60, the yaw gyradius of the weight apportioned to the station, in PUNITS.

NEXT RECORD 6I IS REPEATED FOR  $K = 1$ , NLOADS STATIONS, IF NLOADS > 0.

Record 6I - FORMAT (8F10.4) - required only if NLOADS is greater than 0, omit if 0.

[XLDSTN(I)] (Real) - columns 1-10, 11-20, . . ., station values where loads are to be computed. NLOADS determines the number of load stations that are specified. A load station must correspond exactly to one half of the distance between the successive station numbers specified earlier in this Data Record Set.

Figure 5 illustrates a sample ship contour, with the offset points specified as defined above. This technique is used so that a change in draft can be made by changing only the last point (i.e., at the waterline), or by changing NPTOS in Record 6C when using the variable geometry option.

Data Record Sets 7 through 14 describe the appendages of the given ship; sonar dome, bilge keels, fins, skeg, propeller shafts, propeller shaft brackets, propellers, and rudders. In the case where the ship does not have a particular appendage, a blank record must still be input for that record set. An appendage set may be for a single appendage or for a pair of appendages, as determined by the y-coordinate of the data record set. A single appendage is assumed to be located on the centerline when the y-coordinate is zero. If the y-coordinate is not zero, then another, mirror-image appendage is assumed to exist at the same y-distance on the other side of the hull. An example would be for a pair of bilge keels. No additional input is required for the mirror image of an appendage.

### ***Record Set 7 - Sonar Dome Particulars***

Record 7A - FORMAT (I5) – always required.

[NSDSET] (Integer) - column 5, number of sets of sonar domes (only one set allowed).

0 or blank - No sonar dome input.

1 - Input the sonar dome geometry.

NEXT RECORDS ARE REQUIRED FOR EACH SONAR DOME SET, OMIT IF  
NSDSET=0.

Record 7B - FORMAT (4F10.4)

[SDFST] (Real) - column 1-10, station of the forward-most point of the dome.

[SDAST] (Real) - columns 11-20, station of the aftermost point of the dome.

[SDRWL] (Real) - columns 21-30, top of the dome in PUNITS (typically the baseline = 0.0).

[SDTWL] (Real) - columns 31-40, the lowest point of the dome.

The sonar dome is assumed to be a standard SQS 26 type of dome, which is modeled as a lifting surface with a lift curve slope from experiment.

### ***Record Set 8: Bilge Keel***

Record 8A - FORMAT (I5) – always required.

[NBKSET] (Integer) - column 5, number of sets of bilge keels (maximum of two sets allowed).

0 or blank - No bilge keels input.

1 or 2 - Input the bilge keel geometry.

NEXT RECORDS ARE REQUIRED FOR EACH BILGE KEEL SET, OMIT IF NBKSET=0.

Record 8B - FORMAT (I5,5X,3F10.4)

[NBKSTN] (Integer) - column 5, number of stations crossed by this bilge keel set.

[BKFS] (Real) - columns 11-20, the forward point of the bilge keel set expressed as a station number, e.g., Station 7.75.

[BKAS] (Real) - columns 21-30, the after most point of the bilge keel set expressed as a station number, e.g., Station 12.25.

[BKWD] (Real) - columns 31-40, the span (width) of the bilge keel set in PUNITS.

Note: NBKSTN is the number of stations crossed by this bilge keel set, so that a bilge keel going from Stations 7.75 to 12.25 will cross 5 stations, 8, 9, 10, 11, and 12 with NBKSTN=5 (see Figure 6). In addition, if a bilge keel should start or end exactly at a station, that station must be included.

NEXT RECORD REPEATED FOR THE NBKSTN STATIONS OF THIS BILGE KEEL SET.

Record 8C - FORMAT(4F10.4)

[BKSTN] (Real) - columns 1-10, bilge keel station. Value for BKSTN must correspond exactly to station numbers (STATN) input in Record Set 6.

[BKHB] (Real) - columns 11-20, y-coordinate (positive) where bilge keel attaches to hull

in PUNITS.

[BKWLI] (Real)- columns 21-30, z-coordinate (positive up) where bilge keel attaches to hull.

[BKAN] (Real) - columns 31-40, angle (positive in degrees) that the bilge keel makes to the horizontal.

These records specifically locate the bilge keel in the Input Reference System (see Figure 3) and define the angle that the bilge keel is attached to the hull for each station (see Figure 6).

### ***Record Set 9: Fin***

Record 9A - FORMAT (4I5,2F10.4) – always required.

[NFNSET] (Integer) - column 5, number of sets of fins (maximum of two sets allowed).

0 or blank - No fin input.

1 or 2 - Input the fin geometry.

[IACTFN] (Integer) - column 10, specifies whether the fins are active or fixed.

0 - Fixed fins.

1 - Active fins.

[IFCLCS] (Integer) - column 15, allows the input of an effective lift curve slope for each speed and fin.

0 – No lift curve slope input.

1 - Lift curve slope input.

[IAGC] (Integer) - column 20, specifies whether automatic gain control is used.

0 – No automatic gain control.

1 - Automatic gain control, fin angle and angular rate limits applied.

[FALIM] (Real) – column 21-30, fin angle limit for automatic gain control, deg.

[FVLIM] (Real) – column 31-40, fin angular rate limit for automatic gain control, deg/sec.

NEXT FIVE RECORDS REQUIRED IF IACTFIN = 1, OMIT IF 0.

Record 9B - FORMAT (8F10.4)

[FAREDUCT(I)] (Real) - columns 1-10, 11-20, . . ., speed dependant fin reduction factors applied to the fin angle limit for Automatic Gain Control. One nondimensional factor is required for each speed requested in Data Record Set 2.

Record 9C - FORMAT (8F10.4)

[FGAIN(I)] (Real) - columns 1-10, 11-20, . . ., speed dependant fin gain factors, Gv. One nondimensional gain is required for each speed requested in Data Record Set 2.

Record 9D - FORMAT (3F10.4)

[FK(I)] (Real) - columns 1-10, 11-20, 21-30, fin controller coefficients where FK(1) is proportional to the roll angle, FK(2) is proportional to roll velocity, and FK(3) is proportional to roll acceleration.

Record 9E - FORMAT (3F10.4)

[FA(I)] (Real) - columns 1-10, 11-20, 21-30, fin servo coefficients, where FA(1) is typically 1, FA(2) is proportional to roll velocity, and FA(3) is proportional to roll acceleration.

Record 9F - FORMAT (3F 10.4)

[FB(I)] (Real) - columns 1-10, 11-20, 21-30, fin controller compensation coefficients, where FB(1) is typically 1, FB(2) is proportional to roll velocity, and FB(3) is proportional to roll acceleration.

Nominal values for FK, FA, and FB for a Frigate type ship are shown in Table 3 [19]. FGAIN is either known for existing ships or determined by making iterative runs of SMP.

NEXT RECORD REQUIRED IF IFCLCS = 1, OMIT IF IFCLCS=0.

Record 9G - FORMAT (8F10.4)

[FCLCS(I)] (Real) - columns 1-10, 11-20, . . ., speed dependent effective fin lift curve slope, Lcs, for a particular fin set. Note that record 9G is repeated for each fin set.

NEXT TWO RECORDS REQUIRED FOR EACH FIN SET, OMIT IF NFNSET=0.

Record 9H - FORMAT (5F10.4)

[FNRFS] (Real) - columns 1-10, forward station of root of fin set (see Figure 7).

[FNRAS] (Real) - columns 11-20, aft station of root of fin set.

[FNRHB] (Real) - columns 21-30, y-coordinate (positive) of root of fin set in PUNITS.

[FNRFWL] (Real) - columns 31-40, z-coordinate (positive up from baseline) of forward station of root.

[FNRAWL] (Real) - columns 41-50, z-coordinate of aft station of root.

Record 9I - FORMAT (5F10.4)

[FNTFS] (Real) - columns 1 -10, forward station of tip.

[FNTAS] (Real) - columns 11-20, aft station of tip.

[FNTHB] (Real) - columns 21-30, y-coordinate of tip in PUNITS.

[FNTFWL] (Real) - columns 31-40, z-coordinate of forward station of tip.

[FNTAWL] (Real) - columns 41-50, z-coordinate of aft station of tip.

These two records per fin set respectively define the x, y, z hull geometry coordinates of the root and tip centerline of the fin sets.

### ***Record Set 10: Skeg***

Offsets describing the skeg are required in Record Set 6.

Record 10A - FORMAT (I5) – always required.

[NSKSET] (Integer) - column 5, number of sets of skegs (maximum of two sets allowed).

0 or blank - No skeg input.

1 or 2 - Input the skeg geometry.

NEXT RECORD REPEATED FOR EACH SKEG SET, OMIT IF NSKSET=0.

Record 10B - FORMAT (7F10.4)

[SRFLS] (Real) - columns 1-10, forward station of this skeg set.

[SRALS] (Real) - columns 11-20, aft station of this skeg set at the bottom of the skeg.

[SRAUS] (Real) - columns 21-30, aft station of this skeg set at the top of the skeg.

[SKHB] (Real) - columns 31-40, y-coordinate of skeg set in PUNITS (zero for a skeg on the centerline, see Figure 8).

[SRFLWL] (Real) - columns 41-50, z-coordinate of the forward station of the skeg set (positive up from baseline).

[SRALWL] (Real) - columns 51-60, z-coordinate of aft station at the bottom of skeg set.

[SRAUWL] (Real) - columns 61-70, z-coordinate of aft station at the top of the skeg set.

For each skeg set, this record uniquely defines the x, y, z hull coordinates for the forward, bottom aft, and top aft centerline of the skeg. (See Figure 8).

### ***Record Set 11: Propeller Shafts***

Record 11A - FORMAT (I5) – always required.

[NPSSET] (Integer) - column 5, number of sets of propeller shafts (maximum of six allowed).

0 or blank - No propeller shaft input.

1 to 6 - Input the propeller shaft geometry.

NEXT RECORD REQUIRED FOR EACH SHAFT SET, OMIT IF NPSSET=0.

Record 11B - FORMAT (I5,5X,7F10.4)

[IPSPR] (Integer) – column 5, index of associated propeller in Record Set 13, below.

[PSDIA] (Real) – column 11-20, propeller shaft diameter in PUNITS (see Figure 9).

[PSFST] (Real) - columns 21-30, forward station of shaft set.

[PSFHB] (Real) - columns 31-40, y-coordinate (positive) of forward end of shaft set.



[PSFWL] (Real) - columns 41-50, z-coordinate (positive up) of forward end of shaft set.

[PSAST] (Real) - columns 51-60, aft station of shaft set.

[PSAHB] (Real) - columns 61-70, y-coordinate (positive) of aft end of shaft set.

[PSAWL] (Real) - columns 71-80, z-coordinate (positive up) of aft end of shaft set.

### ***Record Set 12: Propeller Shaft Brackets***

Record 12A - FORMAT (I5) – always required.

[NSBSET] (Integer) - column 5, number of sets of propeller shaft brackets (maximum of two allowed).

0 or blank - No propeller shaft bracket input.

1 or 2 - Input the propeller shaft bracket geometry.

NEXT TWO RECORDS REQUIRED FOR EACH BRACKET SET, OMIT IF  
NSBSET=0.

Record 12B - FORMAT (5F10.4)

[SOBRFS] (Real) - columns 1-10, forward station of outside root of bracket (Figure 10).

[SOBRAS] (Real) - columns 11-20, aft station of outside root of bracket set.

[SOBRHB] (Real) - columns 21-30, y-coordinate (positive) of outside root of bracket set in  
PUNITS.

[SOBRFW] (Real) - columns 31-40, z-coordinate (positive up) of forward station of root.

[SOBRAW] (Real) - columns 41-50, z-coordinate of aft station of root.

Record 12C - FORMAT (5F10.4)

[SBTFS] (Real) - columns 1-10, forward station of tip of bracket set.

[SBTAS] (Real) - columns 11-20, aft station of tip.

[SBTHB] (Real) - columns 21-30, y-coordinate of tip in PUNITS.

[SBTFWL] (Real) - columns 31-40, z-coordinate of forward station of tip.

[SBTAWL] (Real) - columns 41-50, z-coordinate of aft station of tip.

NEXT RECORD REQUIRED IF SHAFT BRACKET IS OFFSET FROM CENTERLINE,  
OMIT IF SBTHB=0.

The program assumes that there is only a single set of struts if SBTHB = 0. The program also assumes that the strut is a vertical strut without an inboard arm if SBTHB = SOBRHB. For the case where the outboard strut arm is vertical with an inboard strut arm, SOBRHB must be entered as slightly outboard of SBTHB.

Record 12D - FORMAT (5F10.4)

[SIBRFS] (Real) - columns 1-10, forward station of inside root of bracket set.

[SIBRAS] (Real) - columns 11-20, aft station of inside root of bracket set.

[SIBRHB] (Real) - columns 21-30, y-coordinate (positive) of inside root.

[SIBRFWJ] (Real) - columns 31-40, z-coordinate (positive up) of forward station of inside root.

[SIBRAW] (Real) - columns 41-50, z-coordinate (positive up) of aft station of inside root.

### ***Record Set 13: Propellers***

Record 13A - FORMAT (I5) – always required.

[NPRSET] (Integer) - column 5, number of sets of propellers (maximum of two allowed).

0 or blank - No propeller input.

1 or 2 - Input the propeller geometry for 1 to 4 propellers.

NEXT TWO RECORDS REQUIRED FOR EACH PROPELLER SET, OMIT IF  
NPRSET=0.

RECORD SET 13B – FORMAT (8F10.4) - required NPRSET times if NPRSET > 0.

[PRST(IS)] (Real) – columns 1-10, station of the propeller hub axis (see Figure 9).

[PRHB(IS)] (Real) – columns 11-20, halfbreadth of the propeller hub axis in PUNITS.

[PRWL(IS)] (Real) – columns 21-30, waterline of the propeller hub axis.

[PDIAM(IS)] (Real) – columns 31-40, propeller diameter.

[TDC(IS)] (Real) – columns 41-50, propeller thrust deduction ( $1 - t$ ).

[WAKET(IS)] (Real) – columns 51-60, propeller thrust wake fraction ( $1 - w_t$ ).

[WAKEQ(IS)] (Real) – columns 61-70, propeller torque wake fraction ( $1 - w_q$ )

[PSRATIO(IS)] (Real) – columns 71-80, ratio of rotation speed of this propeller set to the first propeller set (relevant only if NPRSET > 1, should be one otherwise).

If PRHB not equal 0, it is assumed that there is a pair of propellers equally spaced on either side of the centerline.

RECORD SET 13C – FORMAT (6F10.4) - required NPRSET times if NPRSET > 0:

[CKT(1,IS)] (Real) – columns 1-10, constant coefficient for quadratic fit to  $K_T$  curve.

[CKT(2,IS)] (Real) – columns 11-20, linear coefficient for quadratic fit to  $K_T$  curve.

[CKT(3,IS)] (Real) – columns 21-30, quadratic coefficient for quadratic fit to  $K_T$  curve.

[CKQ(1,IS)] (Real) – columns 31-40, constant coefficient for quadratic fit to  $K_Q$  curve.

[CKQ(2,IS)] (Real) – columns 41-50, linear coefficient for quadratic fit to  $K_Q$  curve.

[CKQ(3,IS)] (Real) – columns 51-60, quadratic coefficient for quadratic fit to  $K_Q$  curve.

$$K_T = CKT(1,IS) + CKT(2,IS) J + CKT(3,IS) J^2.$$

$$K_Q = CKQ(1,IS) + CKQ(2,IS) J + CKQ(3,IS) J^2.$$

RECORD 13D – FORMAT (2I5) - required once if NPRSET > 0.

[IRNFLG] (Integer) – column 5, flag for resistance data or propeller speed data.

1 – Total resistance coefficients.

2 – Propeller speeds.

[NRESC] (Integer) – column 10, number of froude numbers for which resistance or propeller speed data is provided.

RECORD 13E – FORMAT (F10.4,F15.9) – required NRESC times if NPRSET > 0 and IRNFLG = 1.

[FNRESC(I)] (Real) – columns 1-10, Froude number.

[CTOTAL(I)] (Real) – columns 11-25, corresponding total resistance coefficient.

RECORD 13F – FORMAT (F10.4,2F15.9) – required NRESC times if NPRSET > 0 and IRNFLG = 2.

[FNRESC(I)] (Real) – columns 1-10, Froude number.

[NRPSRI (I,J)] (Real) – columns 11-25, 26-40, corresponding propeller speeds, rps for each propeller set.

The Froude number range input must cover the entire speed range that is defined in Record Set 4, as spline interpolation is performed to obtain the shaft speed at the required ship speeds.

#### ***Record Set 14: Rudders***

Record 14A - FORMAT (I5) – always required.

[NRDSET] (Integer) - column 5, number of sets of rudders (maximum of two sets allowed).

0 or blank - No rudder input.

1 or 2 - Input the rudder geometry.

NEXT TWO RECORDS REQUIRED FOR EACH RUDDER SET, OMIT IF NRDSET=0.

Record 14B - FORMAT (5F10.4)

[RDRFS] (Real) - columns 1-10, forward station of root of rudder set (see Figure 11).

[RDRAS] (Real) - columns 11-20, aft station of root of rudder set.

[RDRHB] (Real) - columns 21-30, y-coordinate (positive) of root of rudder set in PUNITS.

[RDRFWL] (Real)-columns 31-40, z-coordinate (positive up from baseline) of forward station of root.

[RDRAWL] (Real) - columns 41-50, z-coordinate of aft station of root.

Record 14C - FORMAT (5F10.4)

[RDTFS] (Real) - columns 1-10, forward station of tip (see Figure 11).

[RDTAS] (Real) - columns 11-20, aft station of tip.

[RDTHB] (Real) - columns 21-30, y-coordinate of tip.

[RDTFWL] (Real) - columns 31-40, z-coordinate of forward station of tip.

[RDTAWL] (Real) -columns 41-50, z-coordinate of aft station of tip.

For each rudder set, the above records define the coordinates of the root and tip centerline of rudder (see Figure 11).

#### ***Record Set 15 - Passive Stabilizers***

RECORD 15A – FORMAT (Unformatted) – always required.

[NPSTBS] (Integer) – any column, number of passive stabilizers (integer, list I/O).

If NPSTBS=zero, no further input is required, and all the stabilizer code will be inoperative. Under current dimensioning, up to three passive stabilizers may be specified, (NPSTBS greater than three is fatal error.)

NEXT RECORD REQUIRED FOR EACH PASSIVE STABILIZER, OMIT IF NPSTBS =0.

RECORD 15B – FORMAT (Unformatted) - requires 13 input numbers. The read statement for each "record" is unformatted. Thus, the 13 numbers are separated by blank(s) and may be continued on multiple lines as long as no comments intervene. Comments before and after each "record" are permitted. Typically, all 13 numbers, to reasonable significance, will fit within the required 80 columns.

[NSTBNO] (Integer) – first columns, an arbitrary stabilizer identification number, limit to

three digits for formatting reasons.

[NSTBTP] (Integer) – next column, the stabilizer type.

1 - U-tube tank.

2 - Free-surface tank.

3 - Moving weight

[NSTBUN] (Integer) – next column, a units flag.

0 - following dimensional variables are input in feet.

1 - input in meters.

Note that the definition of length units MUST be the same as that defined by PUNITS for the ship in Record Set 3.

[XSTB] (Real) - next columns, longitudinal location of stabilizer, NSTBUN units, positive aft of FP.

[GAMST] (Real) - next columns, Stabilizer types 1 and 2: specific gravity of tank fluid relative to that of the sea or fresh water specified in Record Set 3. For fresh water in the tank and the ship in seawater, GAMST is approximately  $= 62.4/64 = 0.975$ . For tanks, the mass density of the fluid is computed as  $\text{GAMST} \times \text{RHO}$ .

Stabilizer type 3: use  $\text{GAMST} = 1.0$  (see discussion of WPINER).

[WPINER] (Real) - next columns, Stabilizer types 1 and 2: the transverse waterplane inertia of the tank liquid ( $\text{feet}^4$  or  $\text{m}^4$ ). DO NOT include the corresponding tank free surface correction in DELGM to GMT in the Record Set 5 input; the dynamic solution takes care of it.

Stabilizer type 3: the volume of sea water equivalent to the mass of the moving weight ( $\text{feet}^3$  or  $\text{m}^3$ ); that is, the mass of the moving weight is computed internally as  $\text{RHO} \times \text{GAMST} \times \text{WPINER}$ .

[OMSTB] (Real) - next columns, the stabilizer natural frequency, rad/sec.

[RSC1] (Real) - next columns, vertical center of gravity of stabilizer, NSTBUN units.

[RSC2] (Real) - next columns, factor for ship KG contribution, non-dimensional.

The variables RSC1 and RSC2 between them define the effective vertical location of the stabilizer relative to the vertical CG of the ship. Internally this height is computed as  $RSC1 - RSC2 * KG$ , with KG found from Record Set 5.

For stabilizer type 1 (see Figure B - 1):

$RSC1 = S''/2$ , half the classical coupling length.

$RSC2 = 0.0$ .

For stabilizer type 2 (see Figure B - 2):

$RSC1 = (\text{distance of tank bottom above keel} + \text{half the water depth})$ .

$RSC2 = 1.0$ .

For stabilizer type 3:

$RSC1 = \text{distance of weight above keel}$ .

$RSC2 = 1.0$ .

[BSTBL] (Real) – next columns, empirical linear stabilizer damping coefficient, fraction of critical.

[BSTBQ] (Real) - next columns, empirical nondimensional quadratic stabilizer damping coefficient. The definition varies somewhat with stabilizer type, see Appendix B.

NOTE: either, but not both, of the damping coefficients may be zero.

[RPSTAB] (Real) - next columns, location of the vertical motion of the tank fluid which is used as the dynamic tank variable, NSTBUN units.

Stabilizer types 1 and 2: transverse offset of center of wing tank.

Stabilizer type 3: use  $RPSTAB=1.0$ , since it is not applicable.

[SATSTB] (Real) - next columns, saturation limit, NSTBUN units.

Stabilizer types 1 and 2, the distance above or below the static tank waterline, at the

lateral offset defined by RPSTAB, where saturation is expected to begin.

For stabilizer type 3, the limit of transverse motion of the weight.

***Record Set 16 - Sinkage and Trim***

Record 16A - FORMAT (I5) – always required.

[STOPTN] (Integer) – column 4-5, sinkage and trim option.

-1 - None.

0 - Bishop and Bales approximation for destroyer hulls (existing SMP option).

1 - Input data.

NEXT RECORD REQUIRED IF STOPTN = 1, OMIT IF STOPTN = -1 or 0.

Record 16B - FORMAT (I5)

[NSTRI] (Integer) – column 5, number of speeds, sinkage and trim records to be read, maximum of 10.

NEXT RECORD REPEATED FOR THE NSTRI SPEEDS

Record 16C - FORMAT (3F10.5)

[FNSTRI] (Real) – columns 1-10, Froude number.

[SNKRI] (Real) – columns 11-20, sinkage in PUNITS at midships, positive down.

[TRMRI] (Real) – columns 21-30, trim in PUNITS as the difference between the bow and stern sinkage, positive bow up.

These values are interpolated over speed and consequently do not need to be changed as requested speeds are changed. They must be in ascending order of Froude number and cover the entire speed range that is defined in Record Set 4.

***Record Set 17 - Wave Profile***

Record 17A - FORMAT (I5) – always required.

[WPOPTN] (Integer) – column 5, wave profile option.

0 - None (existing SMP option).

1 - Input data.

2 - Bishop and Bales approximation for destroyer hulls.

NEXT RECORDS REQUIRED IF WPOPTN = 1, OMIT IF WPOPTN = 0 or 2.

Record 17B - FORMAT (2I5)

[NWPRIFN] (Integer) – column 5, number of Froude numbers for wave profile input to be read, maximum of 12.



15. [NWPRIST] (Integer) – column 10, number of stations for wave profile input, maximum of 15.

NEXT RECORD REPEATED FOR THE NWPRIFN SPEEDS AND NWPRIST STATIONS.

Record 17C - FORMAT (3F10.5)

[FNWPRI(I)] (Real) – columns 1-10, Froude number for the wave profile.

[STWPRI (J,I)] (Real) – columns 11-20, station for wave elevation, may vary with speed.

[WPRZRI(J,I)] (Real) – columns 21-30, wave elevation at the station, in PUNITS, positive up.

These values must be in ascending order of Froude number and cover the entire speed range that is defined in Record Set 4. These values are interpolated over speed and consequently do not need to be changed as requested speeds are changed.

The NWPRIST station values, STWPRI, must be in ascending order for each Froude number and then repeated for each successive Froude number. Outside the range of STWPRI, the wave profile is assumed to be zero. For best results, the wave profile at the first and last stations should be zero. The stations at which the wave profile values are given need not be at exactly the desired deck wetness calculation stations. Note that the range of stations may vary with speed, but the number of stations must be NWPRIST for all speeds. Note also that the stations as well as the elevations are interpolated over speed using splines, so the values should vary smoothly.

#### ***Record Set 18: Roll Damping Model Selection***

Record 18 – No input read, for future development only.

#### ***Record Set 19: Stop***

Record 19 - FORMAT (A4) – always required.

[STOP] (Character) - columns 1-4, STOP (last record to be read).

## **SMPIRGW Record Set Description**

This particular section on the description of the record sets is an illustrative formulation on how to prepare an SMP SMPIRGW input file. It is an important section to which the user should constantly refer before running a ship through SMP. Thus, careful reading of this section is highly recommended.

Note that each data record set is made up of one or more records. Any specific data record set that should not be used is represented by a blank record. It should also be noted that some records within a data record set may be eliminated or omitted, depending on the user's needs and information. The method used to describe each data record set is to list each record, its FORTRAN format, and the variable(s) contained in it.

The SMPIRGW run must be preceded by a SMPREGW or SMP95 run using the same input 'Ship' file name as described in the Starting the Program section.

### ***Record Set 1: Title***

Record 1 - FORMAT (20A4) – always required.

[TITLE] (Character) - columns 1-80, title information.

This is a one-record data set consisting of up to 80 characters. The title should be centered on the record and usually includes the ship, date, project, and/or other parameters that make this run unique. This information will be output at the top of each printed page. For historical reference, the user may desire to cite the ship's draft and trim on this title record.

### ***Record Set 2: Program Options***

Record 2 - FORMAT (8I5) – always required.

[RAOPRNOPTN] (Integer) – column 5, option to output ship motion response amplitude operators, RAO. The RAO tables are printed for the six-degree-of-freedom motions for the user-specified significant wave heights in Record Set 4, and for each speed, heading, and wave frequency defined in SMPREGW. It should be noted that the lateral motion RAO's are nonlinear with sea state. The user should also be aware of the large amount of output generated when this option is selected.

0 - None output.

1 - Output RAO data.

2 - Output ship response transfer functions, TF, for wave frequencies.

3 - Output ship response transfer functions, TF, for specified wave slope.

[LRAOPRNOPTN] (Integer) – column 10, load RAO print option to output the vertical and

horizontal shear force and bending moment response amplitude operators (LRAO) and phase angles in SMPIRGW. A load RAO file (LRAFIL) is generated only when the LRAOPR option is selected.

0 - None output.

1 - Output LRAO data.

[RSVPRNOPTN] (Integer) – column 15, option to output ship response statistical values, RSV.

0 - None output.

1 - Output RSV data.

[VLACPR] (Integer) – column 20, option to output RMS velocities and accelerations. Because the standard SMP output is extensive, care should be exercised when selecting this option. The RSV output will triple when this option is selected and the velocity and acceleration print switches below are used in SMPIRGW. The velocities and accelerations are always written out to the Speed Polar file, so the user may prefer to plot this data rather than print it out.

0 or blank - No velocity and acceleration output.

1 - Output the velocity and acceleration RSV/ $T_{0E}$  tables.

[SEVPRNOPTN] (Integer) – column 25, option to print severe motion table.

0 - None output.

1 - Severe motion tables are output under the same conditions as for SMP84.

2 - Severe motion tables are output as defined in Record 7F below.

[LCOPTN] (Integer) – column 30, option to select longcrested seas.

0 - None output.

1 - Output longcrested seas RSV data.

[SCOPTN] (Integer) – column 35, option to select shortcrested seas.

0 - None output.

1 - Output shortcrested seas RSV data.

[TOEOPTN] (Integer) – column 40, option to select encountered modal periods ( $T_{0ES}$ ) for all responses.

0 - None output.

1 - Output encountered modal periods ( $T_{0ES}$ ) for all responses.

This is a one-record data set that enables the user to control the extent of program execution and the amount of data printed. Eight option variables are contained on this record set.

### ***Record Set 3: Roll Iteration***

Record 3 - FORMAT (F10.4,5A4)

[STATIS] (Real) - columns 1-10, single amplitude statistic used for calculation of responses in irregular seas. Table 4 [1] is provided to assist the user in selecting an appropriate value. The default for STATIS is significant, 2.0.

[STATNM] (Character) - columns 11-30, statistic name (default is SIGNIF. SA).

### ***Record Set 4: Seaway Description***

Record 4A - FORMAT (I5,5X,F10.4) – always required.

[IWVSPC] (Integer) - column 5, number of significant wave heights (sea states).

0 - Bretschneider wave spectrum.

1 - Jonswap wave spectrum.

2 - Ochi-Hubble six-parameter wave spectrum - most probable.

3 - Ochi-Hubble six parameter wave spectrum - all cases.

4 - Ochi-Hubble six parameter wave spectrum – input arbitrary parameters.

[GAMMA] (Real) - columns 11-20, JONSWAP Spectrum peak factor is number of times greater than Bretschneider spectrum peak, usually a value of 3.3. Values of 1.0 or less default to Bretschneider spectrum. Values greater than 4.0 are limited to 4.0. The JONSWAP spectrum is based on the North Sea data and is used for coastal regions.

Record 4B - FORMAT (I5) – always required.

[NSIGWH] (Integer) - column 5, number of significant wave heights (sea states).

The maximum value for NSIGWH is 20, while the default is 4. If IWVSPC = 3, NSIGWH must be 1.

NEXT RECORD REQUIRED IF NSIGWH > 0, OMIT IF IWVSPC = 4.

Record 4C - FORMAT (8F10.4)

[SIGWH] (Real) - columns 1-10, 11-20, . . ., significant wave height to be used with each of NSIGWH wave spectra, in PUNITS (SMPREGW Data Record Set 3).

The four default values of significant wave height (set when NSIGWH = 0) are 1, 1.5, 2, and 3 meters corresponding to Sea States 2, 3, 4, and 5 for ships with roll periods < 9 seconds. Significant wave heights of 1.5, 2, 3, and 5 meters corresponding to Sea States 3, 4, 5, and 6 for ships with roll periods between 9 and 15 seconds. Significant wave heights of 2, 3, 5, and 7.5 meters corresponding to Sea States 4, 5, 6, and 7 are used for ships with roll periods > 15 seconds. If IWVSPC = 2, 3, or 4 defaults are not applicable.

NEXT TWO RECORDS REQUIRED IF NSIGWH > 0, OMIT IF IWVSPC > 1.

Record 4D - FORMAT (I5)

[NTMOD] (Integer) – column 5, number of modal wave periods, maximum of 15.

Record 4E - FORMAT (8F10.4)

[TMODAL] (Real) – columns 1-10, 11-20, . . . , NTMOD modal periods of wave spectrum, in seconds.

NEXT RECORD REPEATED FOR NSIGWH WAVE HEIGHTS IF IWVSPC = 4, OMIT OTHERWISE.

Record 4F - FORMAT (6F10.4)

[HS1] (Real) – columns 1-10, significant wave height for first peak, in PUNITS.

[WS1] (Real) – columns 11-20, modal frequency for first peak, in radians/second.

[LAMBDA1] (Real) – columns 21-30, shape parameter for first peak (1 = Bretschneider).

[HS2] (Real) – columns 31-40, significant wave height for second peak, in PUNITS.

[WS2] (Real) – columns 41-50, modal frequency for second peak, in radians/second.

[LAMBDA2] (Real) – columns 51-60, shape parameter for second peak (1 = Bretschneider).

These variables define the Arbitrary Ochi-Hubble spectrum parameters.

NEXT TWO RECORDS REQUIRED IF RAOPRNOPT = 3, OMIT OTHERWISE.

Record 4G - FORMAT (I5)

[NWSLOPE] (Integer) – column 5, number of wave slopes, maximum of 20. (No default value).

Record 4H - FORMAT (8F10.4)

[WSLOPE] (Real) – columns 1-10, 11-20, . . . , "wave slope numbers", with  $2 A / \text{Lambda} = 1 / \text{WSLOPE}$ , where A is the wave amplitude and lambda is the wave length. For example, the wave slope specified as 30 for a slope of 1/30. (No default values).

Note: When using RAOPTN = 3 for wave slope, the wave slope must be specified in the following way: In Record set 4 - specify Bretschneider, one wave height and period - for significant wave height use the wave slope specified as 30 for a slope of 1/30.

RSV/T<sub>0E</sub> tables are output and Speed Polar files saved for the statistic and significant wave heights that are input in this record set. Additional tables and files for other statistics and/or significant wave heights are easily obtained by running the program again with different input.

### ***Record Set 5: Motions at a Point***

Record 5A - FORMAT (I5) – always required.

[NPTLOC] (Integer) - column 5, number of points on the hull where absolute motions in the longitudinal, lateral, and vertical directions are to be computed (maximum of ten points). The six-degree-of-freedom motions, surge, sway, heave, roll, pitch, and yaw are computed irrespective of the value of NPTLOC.

NEXT RECORD REPEATED FOR EACH NPTLOC POINT, OMIT IF NPTLOC=0.

Record 5B - FORMAT (I5,5X,8A4,8X,3F10.4)

[PTNUMB] (Integer) - column 5, number assigned to point.

[PTNAME] (Character) - columns 11-42, name assigned to point.

[XPTLOC] (Real) - columns 51-60, x-coordinate (station number) of point (see Figure 3).

[YPTLOC] (Real) - columns 61-70, y-coordinate of point (positive to port from centerline) in PUNITS.

[ZPTLOC] (Real) - columns 71-80, z-coordinate of point (positive up from baseline).

#### ***Record Set 6: Relative Motion***

Record 6A - FORMAT (I5) – always required.

[NFREBD] (Integer) - column 5, number of points on hull where relative motions are to be computed (maximum of 12 points).

NEXT RECORD REPEATED FOR EACH NFREBD POINT, OMIT IF NFREBD=0.

Record 2 - FORMAT (I5,5X,8A4,8X,3F10.4)

[FBNUMB] (Integer) - column 5, number assigned to point.

[FBNAME] (Character) - columns 11-42, name assigned to point.

[XPTFBD] (Real) - columns 51-60, x-coordinate (station number) of point (see Figure 3).

[YPTFBD] (Real) - columns 61-70, y-coordinate of point (positive to port from centerline) in PUNITS.

[ZEFFBD] (Real) - columns 71-80, z-coordinate of point (positive up from baseline).

#### ***Record Set 7: Ship Responses***

Record 7A - FORMAT (3I5) – always required.

[ORGRSP(1)] (Integer) – column 4-5, displacement for 6DOF responses.

[ORGRSP(2)] (Integer) – column 9-10, velocity for 6DOF responses.

[ORGRSP(3)] (Integer) – column 14-15, acceleration for 6DOF responses.

0 – No data output.

1 – Motions data output.

11 – Motions data with modal periods of motions output.

NOTE: All three motions components will be calculated in each case.

NEXT RECORD REPEATED FOR EACH NPTLOC POINT, OMIT IF NPTLOC=0

Record 7B - FORMAT (7I5)

[PTRSP(1,K)] (Integer) – column 4-5, displacement for translations in x, y and z directions.

[PTRSP(2,K)] (Integer) – column 9-10, velocity for translations in x, y and z directions.

[PTRSP(3,K)] (Integer) – column 14-15, acceleration for translations in x, y and z directions.

[PTRSP(4,K)] (Integer) – column 19-20, longitudinal and lateral accelerations in the body axis (Ship) coordinate system.

[PTRSP(5,K)] (Integer) – column 24-25, Motion Sickness Incidence.

[PTRSP(6,K)] (Integer) – column 29-30, Motion Interruption induced by sliding.

[PTRSP(7,K)] (Integer) – column 34-35, Motion Interruption induced by tipping.

0 – No data output.

1 – Motions data output.

11 – Motions data with modal periods of motions output.

These switches control output for responses at the Kth point location specified in Record Set 5b.

NEXT RECORD REQUIRED IF PTRSP(5,K), PTRSP(6,K), OR PTRSP(7,K) > 0, OMIT OTHERWISE.

Record 7C - FORMAT (7F10.4)

[OBJCG] (Real) – columns 1-10, vertical CG of object/person relative to ZPTLOC(K), used in tipping and sliding calculations, default value = 3 feet or 0.91 meters.

[XMU] (Real) – columns 11-20, coefficient of friction for sliding, must be between 0 and 1, default value = 0.4, for shoe on interior tile floor. On dry non-skid deck XMU is at least 1.0.

[MSITIM] (Real) – columns 21-30, motion sickness time interval, hours, default value = 4.

[LONTIP] (Real) – columns 31-40, longitudinal tipping coefficient, default value = 0.165.

[LATTIP] (Real) – columns 41-50, lateral tipping coefficient, default value = 0.233.

[TRIML] (Real) – columns 51-60, longitudinal trim angle, degrees, default value = 0.0.

[HEEL] (Real) – columns 51-60, lateral heel angle, degrees, default value = 0.0.

NEXT RECORD REPEATED FOR EACH NFREBD POINT, OMIT IF NFREBD = 0

Record 7D - FORMAT (7I5)

[RMRSP(1,K)] (Integer) – column 4-5, relative motion displacement.

[RMRSP(2,K)] (Integer) – column 9-10, relative velocity.

[RMRSP(3,K)] (Integer) – column 14-15, slamming occurrences.

[RMRSP(4,K)] (Integer) – column 19-20, propeller tip emergences.

[RMRSP(5,K)] (Integer) – column 24-25, wetnesses or submergences.

[RMRSP(6,K)] (Integer) – column 29-30, slam pressures (Ochi-Motter [12] or Stavovy-Chuang [13]).

[RMRSP(7,K)] (Integer) – column 34-35, slam forces (Schmitke [14]).

0 – No data output.

1 – Motions data output.

11 – Motions data with modal periods of motions output.

These switches control output for responses at the Kth point location specified in Record Set 6b.

The threshold velocity used only in slamming occurrence computations has a default value of 12 Lpp/520 in English units or 3.66 Lpp/158.5 in metric units. This value is based on slam model tests of the Mariner hull form at Station 3, which are scaled by ship length only. The Ochi-Motter [12] and Stavovy-Chuang [13] methods calculate the slamming pressure for the input section shape. The equivalent slam pressure for Mariner Station 3 is 15 psi or 100 kPa.

NEXT RECORD REQUIRED IF RMRSP(6,K) OR RMRSP(7,K) > 0, OMIT OTHERWISE.

Record 7E - FORMAT (I10,5F10.4)

[K] (Integer) – columns 9-10, index of slam pressure or force point, maximum of 12.

[HWB] (Real) – columns 11-20, half width of flat bottom at slam station.

[DRANGL] (Real) - columns 21-30, deadrise angle in degrees at slam station.

< or = 0 – Ochi-Motter [12] method used to compute form factor.

> 0 – Stavovy-Chuang [13] truncated wedge method used to compute form factor.

[ALPHA] (Real) – columns 31-40, probability of exceedance parameter for calculation of extreme slamming pressure for design consideration, often 0.01 for 1% exceedance.

[SDRAFT] (Real) – columns 41-50, draft at slam station.

[HRS] (Real) – columns 51-60, number of hours of ship operation time for slamming.

Note: If K does not agree with the slam point index in Record 7D, the program stops.

NEXT FOUR RECORDS REQUIRED FOR DRANGL ≤ 0, OMIT OTHERWISE.

If Ochi-Motter [12] method used to compute the form factor, the following data must be provided, starting at the keel or at the edge of the flat bottom. The vertical extent must equal or exceed ten percent of the local draft. The input format is the similar to that for hull section input in SMPREGW Record Set 6. Knuckles are allowed. This section data will be interpolated to obtain section data at the exact waterlines required by the Ochi-Motter method.

Record 7E2 - FORMAT (F10.4,2I5)

[STASLM] (Real) – columns 1-10, station for slam pressure section data.



[NP] (Integer) – column 15, number of points on slam pressure station, maximum 70.

[KFS] (Integer) – column 20, knuckle flag.

0 - No knuckles on station.

1 - Knuckles on station.

Record 7E3 - FORMAT (F10.4,10F7.2,6(10X,10F7.2)) – always required.

[STASLM] (Real) – columns 1-10, station for slam pressure section data (see Figure 5).

[HLFBSL(J)] (Real) - columns 11-17, 18-24, . . . , [(NP-1)\*7+11] - [NP\*7+10], slam station halfbreadth y-coordinates in PUNITS for NP offsets (referenced to the centerline, always positive), repeated for as many lines as required.

Record 7E4 - FORMAT (F10.4,10F7.2,6(10X,10F7.2)) – always required.

[STASLM] (Real) – columns 1-10, station for slam pressure section data.

[WTRLNE(J)] (Real) - columns 11-17, 18-24, . . . , [(NP-1)\*7+11] – [NP\*7+10], slam station waterline z-coordinates for NP offsets (referenced to the baseline, positive up), repeated for as many lines as required.

Record 7E5 - FORMAT(10X,10(6X,I1)) - required if KFS equals 1.

[KFS (J)] - columns 17, 24, . . . , J=1, NP), slam section offset knuckle flag for NP offsets, repeated for as many lines as required.

0 - No section offset knuckle at this point.

1 - Section offset knuckle at this point.

Note: The Schmitke [14] slam force code is included to preserve it; its validity needs to be established.

NEXT RECORD REQUIRED IF SEVPRNOPTN = 2, OMIT OTHERWISE.

Record 7F – FORMAT (I5)

[NSEVINP] (Integer) – column 5, number of Severe Motion points, maximum 13.

NEXT NSEVINP RECORDS REQUIRED IF NSEVINP > 0, OMIT OTHERWISE.

Record 7F2 – FORMAT (3I5,5X,A60)

[IPTSEV(I)] (Integer) – column 5, Severe Motion point index, 0-10.

0 – Center of Gravity, 1 to 10 – At motion points as defined in Record Set 5.

[IMTSEV(I)] (Integer) – column 10, Severe Motion mode index, 1-6.

1 – Surge, 2 – Sway, 3 – Heave, 4 – Roll, 5 – Pitch, 6 – Yaw.

[ITTSEV(I)] (Integer) – column 15, Severe Motion type index, 1-3

1 – Displacement, 2 – Velocity, 3 – Acceleration.

[RSPNME(I)] (Character) – column 21-80, Severe Motion point label.

This input allows definition of the Severe Motion table that is different from the default.

Record 7G – FORMAT (5I5) – always required.

[LDRSP(1)] (Integer) – column 5, Horizontal Shear Force.

[LDRSP(2)] (Integer) – column 10, Vertical Shear Force.

[LDRSP(3)] (Integer) – column 15, Torsional Moment.

[LDRSP(4)] (Integer) – column 20, Horizontal Bending Moment.

[LDRSP(5)] (Integer) – column 25, Vertical Bending Moment.

0 – No data output.

1 – Loads data output.

11 – Loads data with modal periods of loads output.

Load Responses are output at the load stations specified in the SMPREGW input file.

### ***Record Set 8: Stop***

Record 1 - FORMAT (A4) – always required.

[STOP] (Character) - columns 1-4, STOP (last record to be read).

## **Common Problems**

### **Input Records**

The most common error experience when running SMP is a formatting problem with the input file. SMP uses formatted records for input, therefore, the column position of each data item is critical. The following rules should be followed:

- a. Integers are right justified within their specified fields.
- b. Floating point (real) numbers are right justified within their specified fields.
- c. Character strings are left justified within their specified fields.

### **Input Geometry**

There are several critical features that need to be contained in the input geometry record set. These features are outlined below:

- a. Points on the station should be placed in equal girth increments, for best fit of the splines used in SMP.
- b. There should be at least three points in the bilge radius area for the correct computation of the bilge damping terms.
- c. Station 10 must be included.
- d. Half-Breadth of the forward most station that pierces the free surface must be 0.
- e. Skegs should be included in the station offsets.

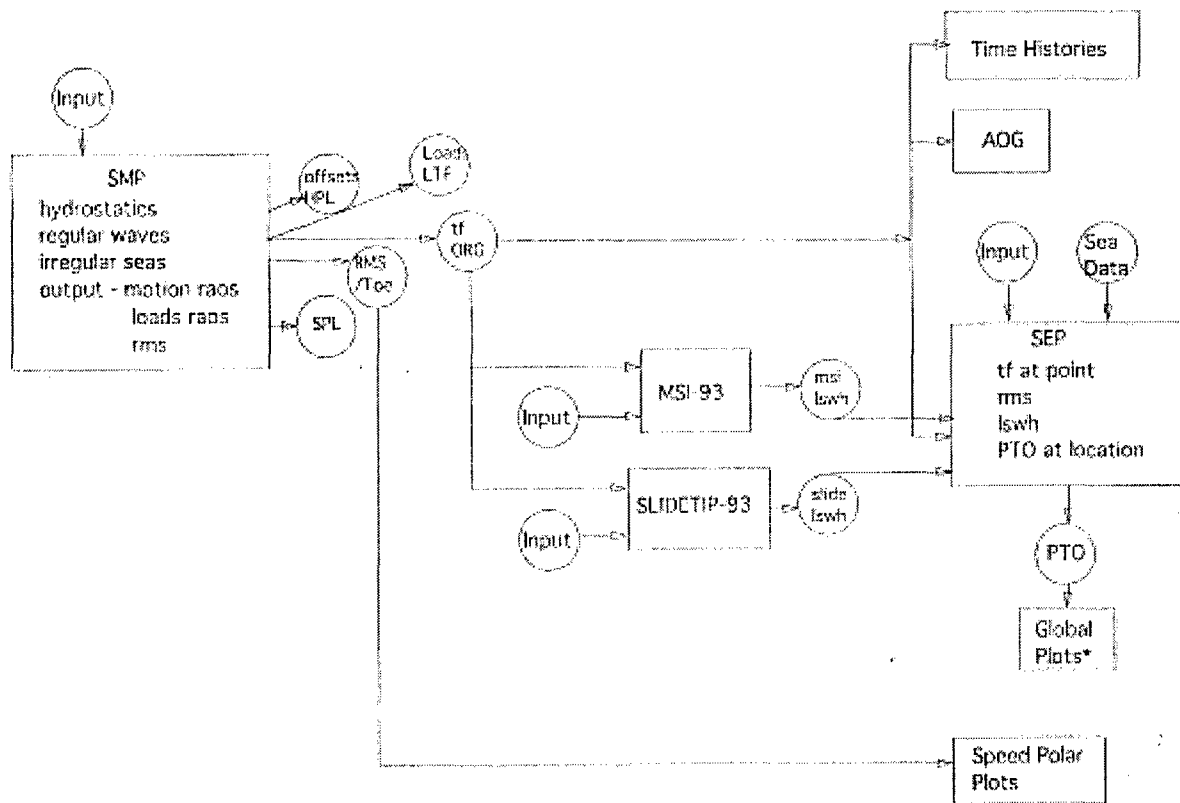
### **Matching Roll**

If the computed roll period does not match the expect value, the problem may be due to several factors. First, the appendage record sets should be carefully checked to ensure that they are correct. The second factor is a limitation in the ability of SMP95 to predict non-linear roll. The user can make small adjustments in the bilge keel and skeg record sets to correct the roll period prediction.

## **Acknowledgements**

The author acknowledges the extensive SMP95 program development work by William McCreight, William Meyers, John O'Dea, and the late John Dalzell that is only now being published.

## CURRENT MONOHULL PREDICTIONS



Internal files are not listed.  
Each program has a printer output file.

**Figure 1. SMP93-PC Program Structure**

## SMP95 STRUCTURE

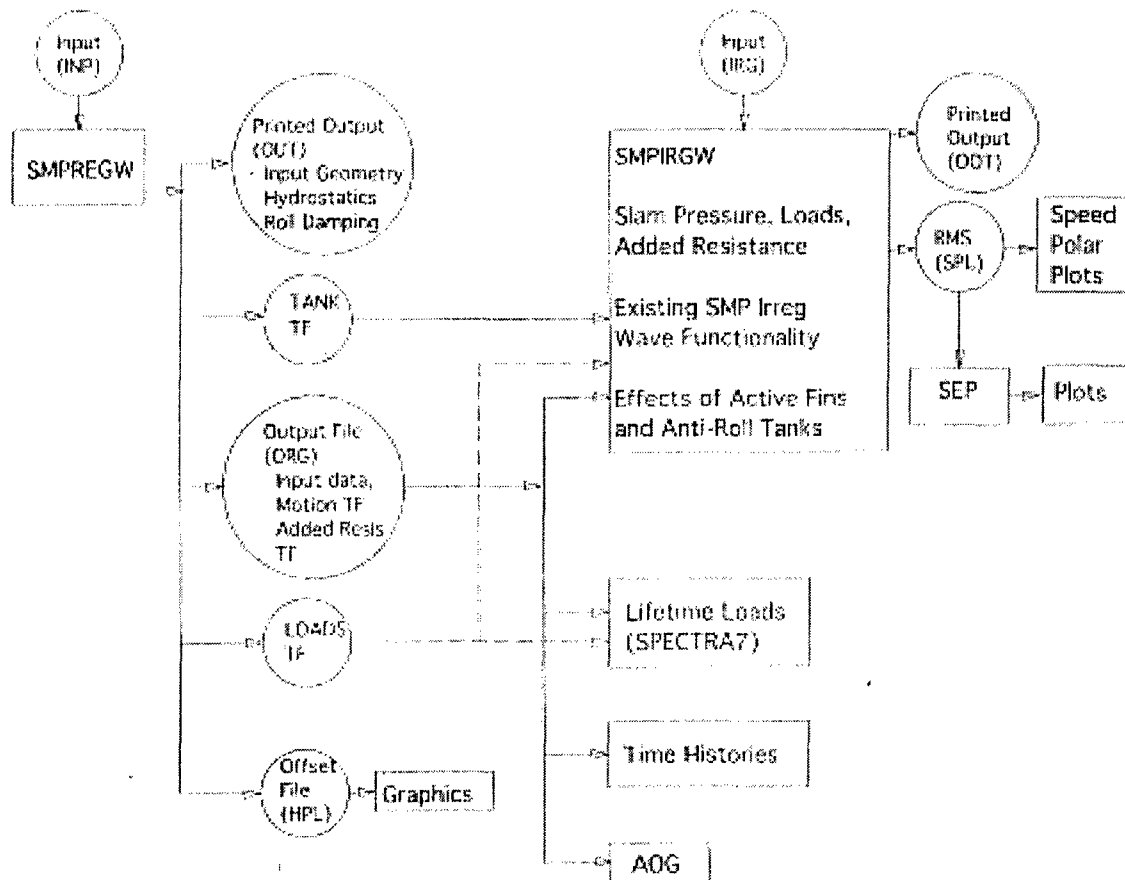


Figure 2. SMP95 Organization Structure

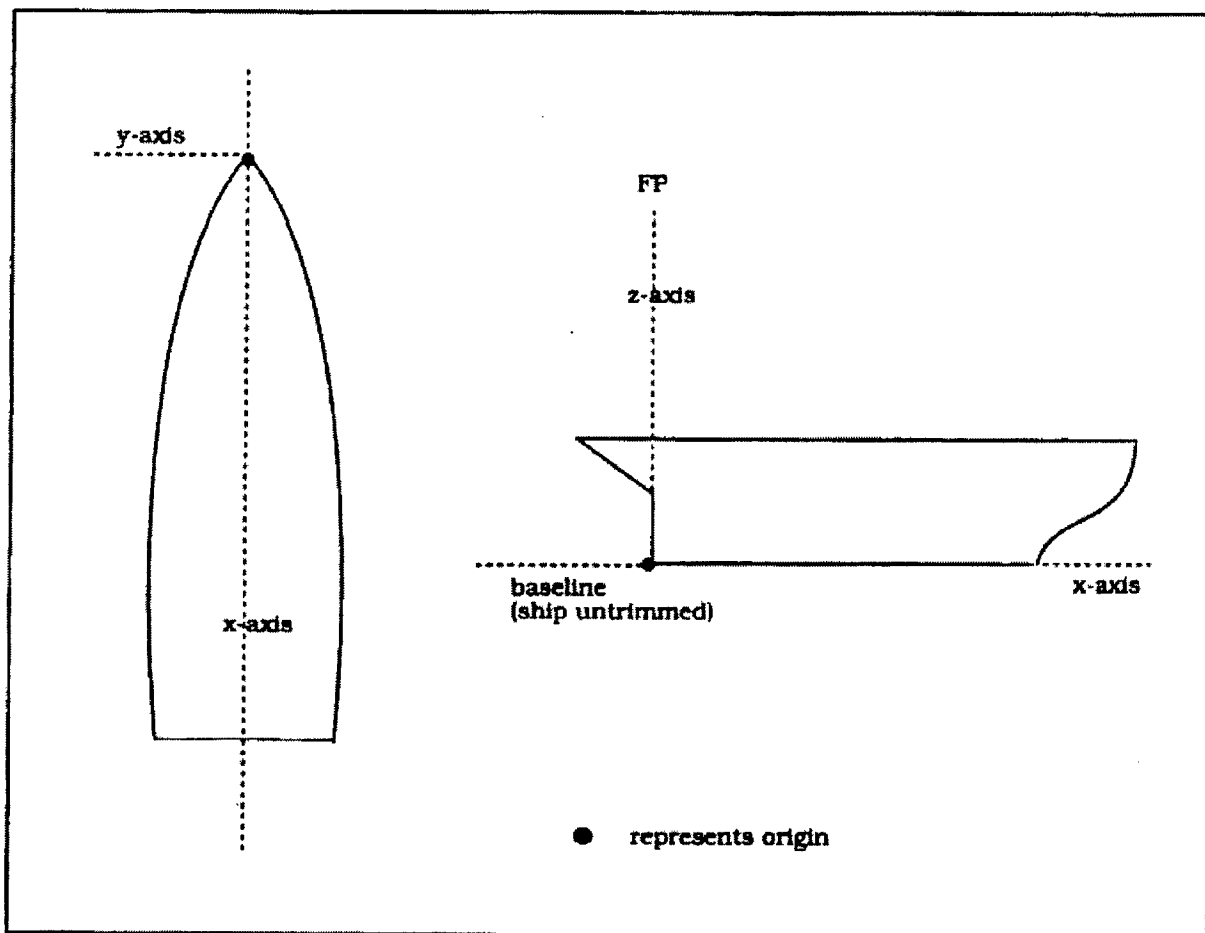


Figure 3. SMP Input Reference System

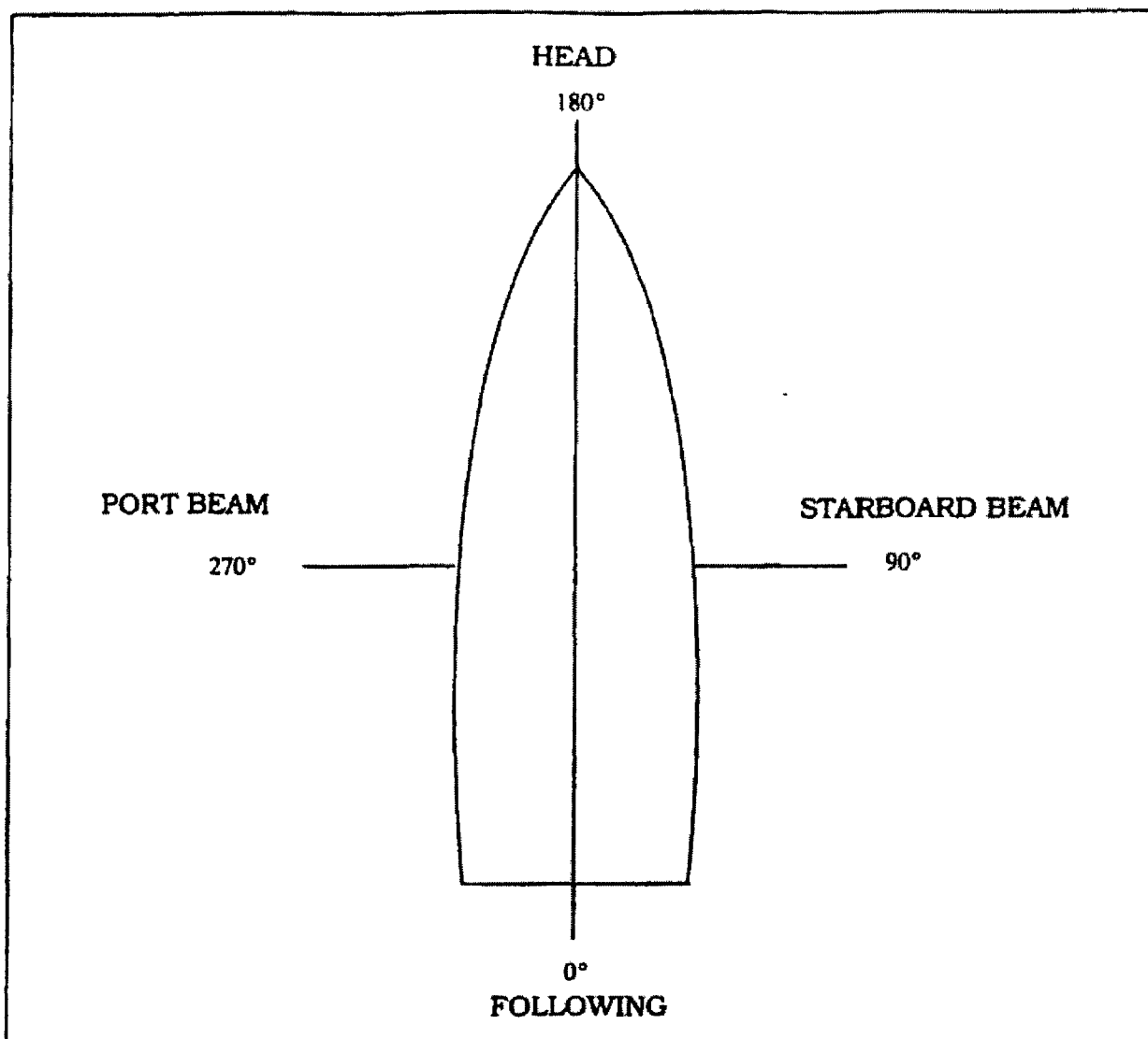


Figure 4. Internal SMP Heading Conventions

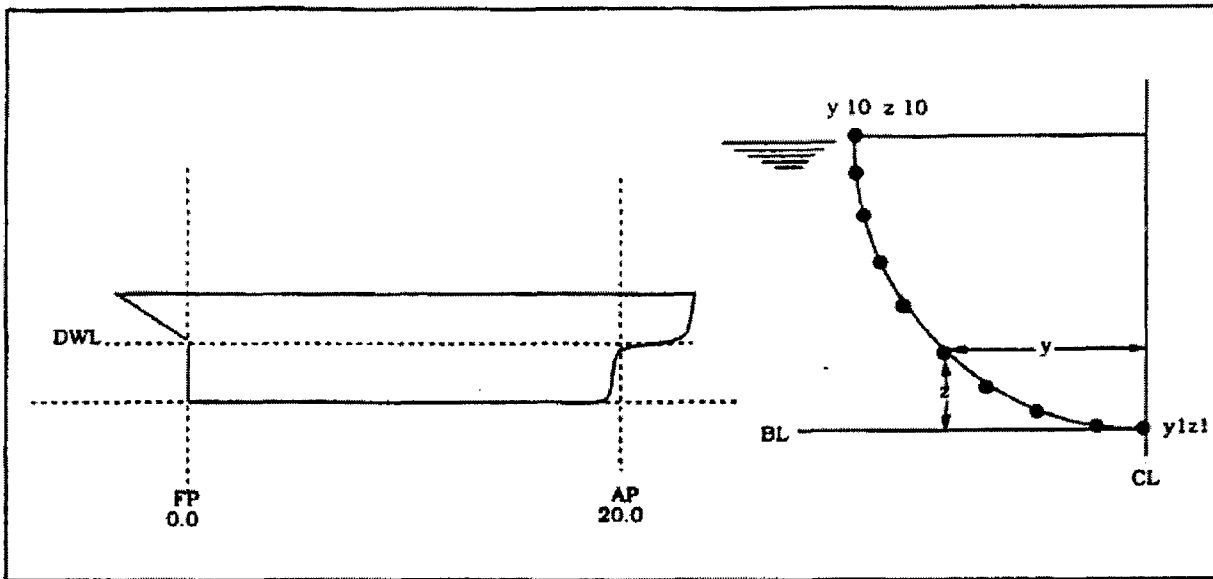


Figure 5. Example of Dividing a Ship into Stations and Typical Station Offsets

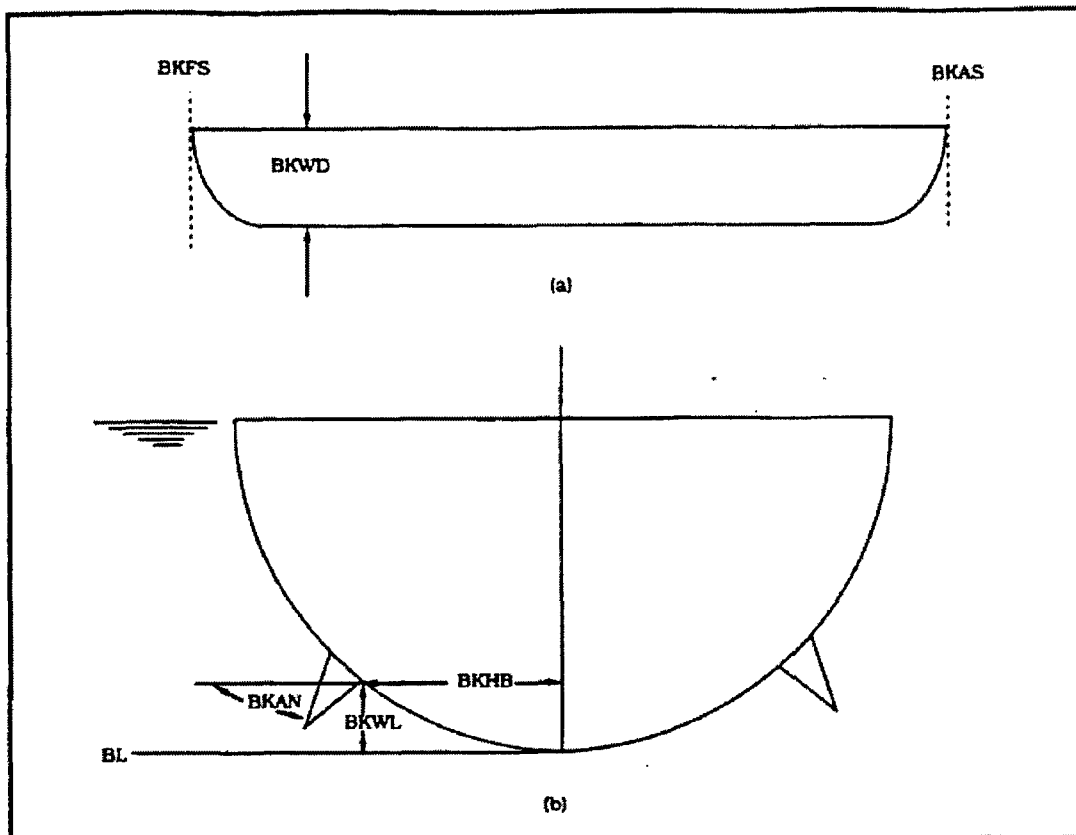


Figure 6. Bilge Keel Input Definitions



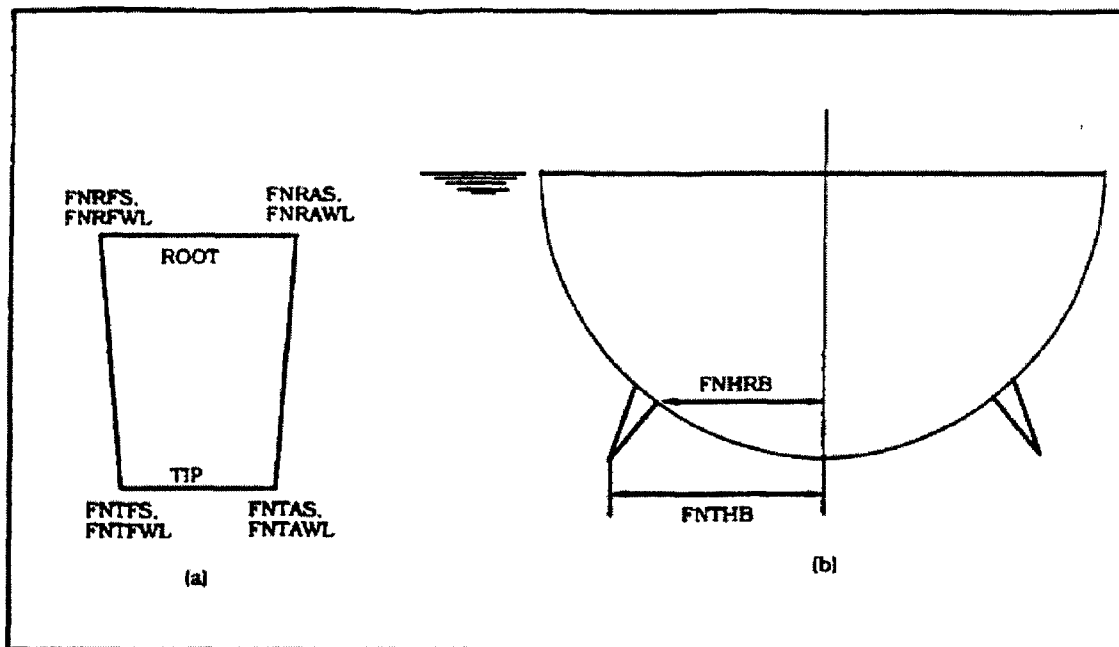


Figure 7. Stabilizer Fin Input Definitions

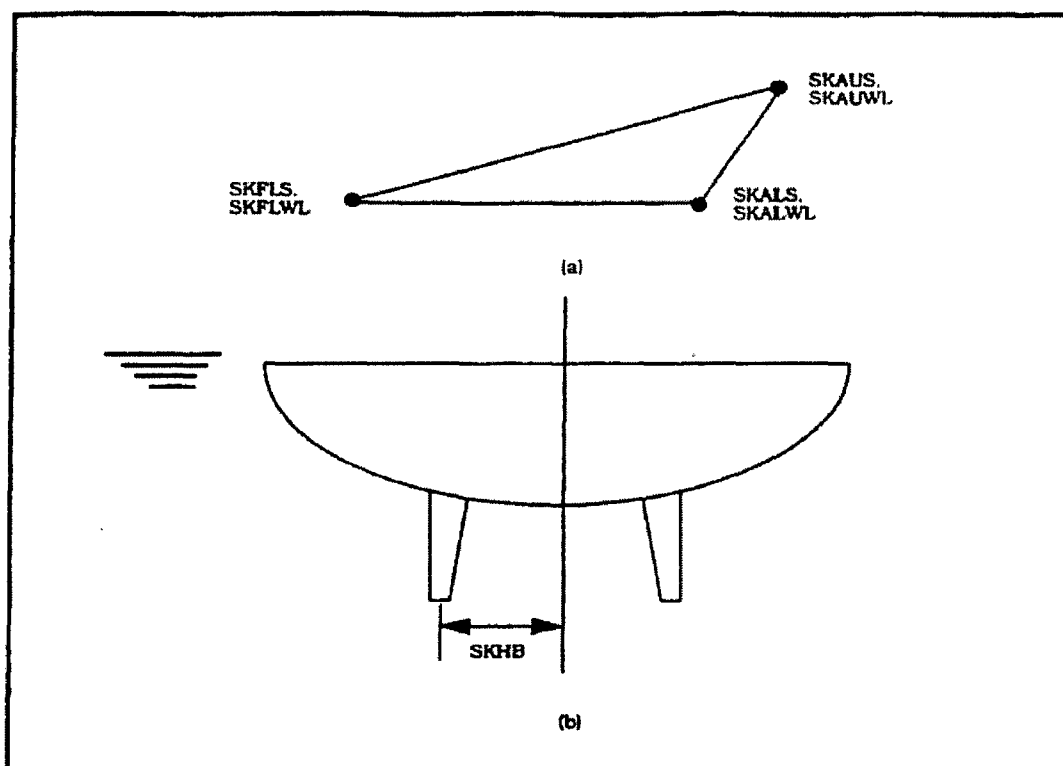


Figure 8. Skeg Input Definitions

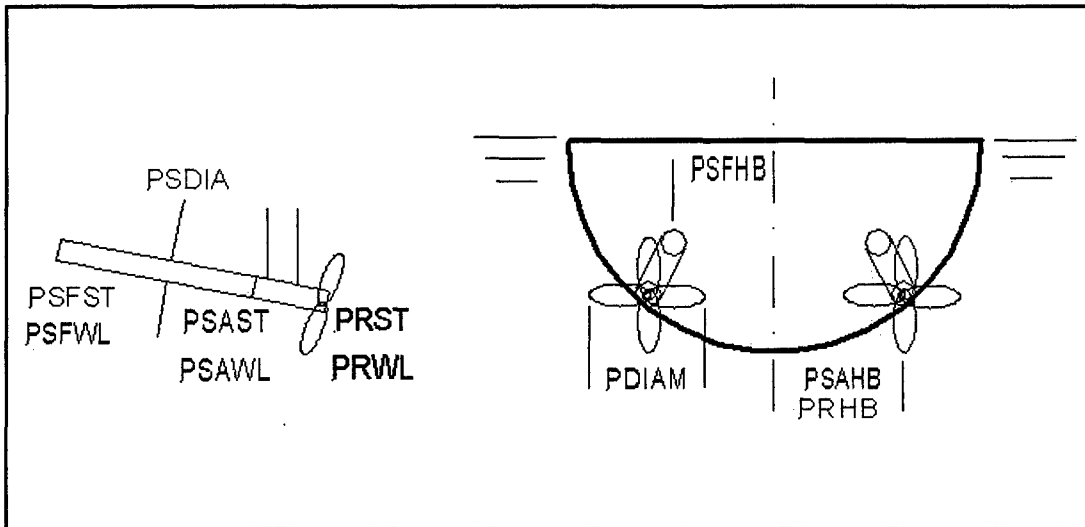


Figure 9. Propeller Shaft and Propeller Input Definitions

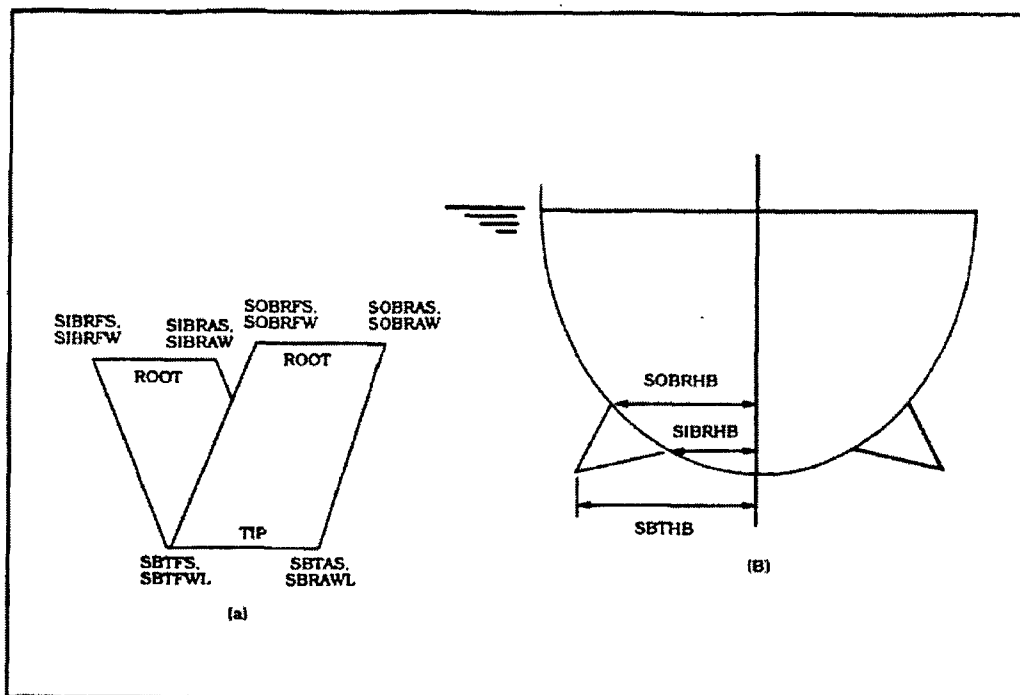


Figure 10. Propeller Shaft Bracket Input Definitions

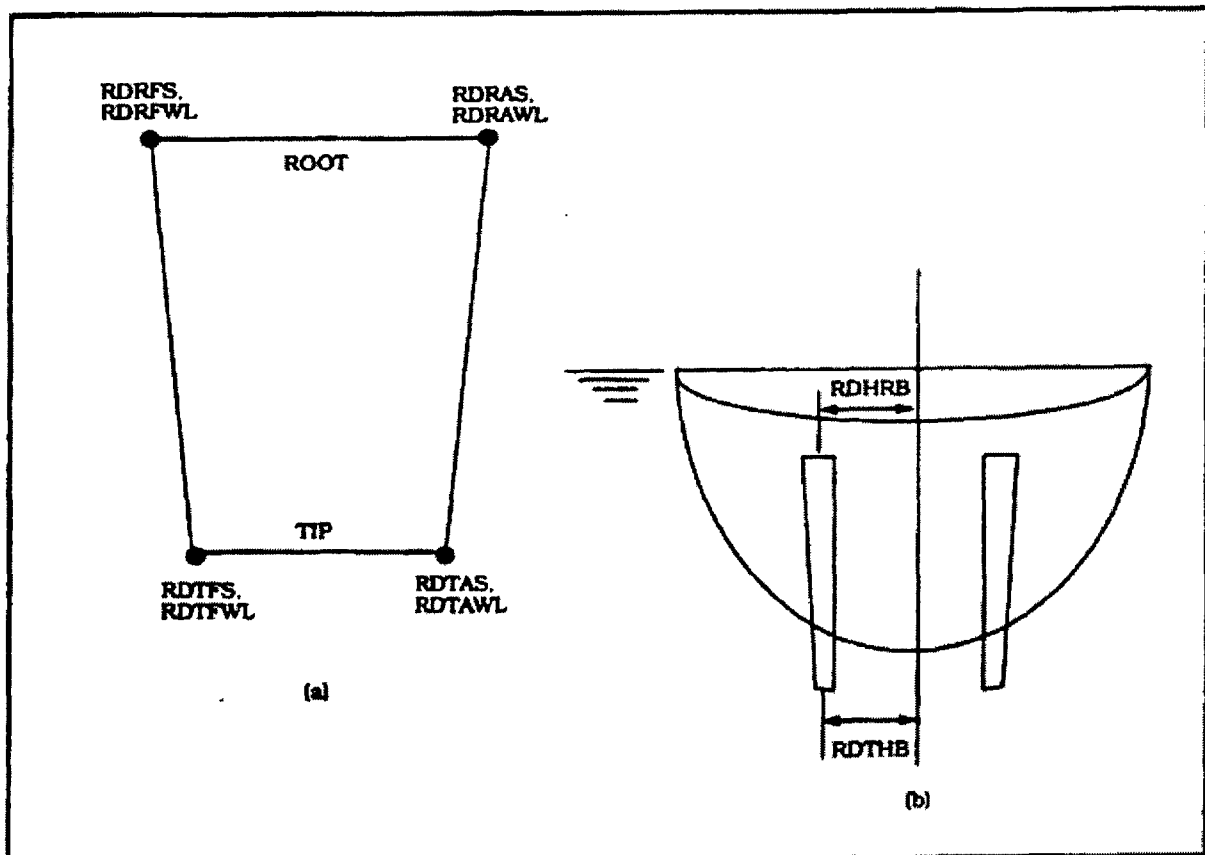


Figure 11. Rudder Input Definitions

**Table 1. Program File Contents**

<b>File Name</b>	<b>Unit</b>	<b>Input/Output</b>	<b>Contents</b>
SYSFIL	1	In or Out	System Paths, Names
INPFIL Reg*.inp, Irg*.irg	5	In	Input Record Sets
LOGFIL Reg*.log, Irg*.lgg	6	Out	Log Time, Errors
PRNFIL Reg*.out, Irg*.oot	7	Out	Printed Output
SCRFIL	8	Out or In	Scratch File
HPLFIL Reg*.hpl	9	Out	Ship Hull Offsets
LRAFIL Irg*.lra	10	Out	Load Response Amp Operators
ORGFIL Reg*.org, Irg*.org	11	Out or In	Origin Transfer Functions
SEVFIL Irg*.sev	12	Out	Severe Motion Table
SPLFIL Irg*.spl	13	Out	Motion Speed Polar Plot
LTFFIL Reg*.ltf, Irg*.ltf	14	Out or In	Load Transfer Functions
PTFFIL Reg*.ptf, Irg*.ptf	15	Out or In	Roll Tank Transfer Functions
SLMFIL Irg*.slm	16	Out	Slam Speed Polar Plot
TABFIL Irg*.tab	17	Out	Tab Delimited Output
BNTFIL Reg*.bnt	18	Out	Beck-Newman-Tuck Section Areas
SPDFIL Irg*.spd	19	Out	Motions for POLARPLOT

Reg\* = RegFile.ext is SMPREGW File

Irg\* = IrgFile.ext is SMPIRGW File

**Table 2. Record Set Summary**

<b>Record Set</b>	<b>SMPREGW Definition</b>	<b>SMPIRGW Definition</b>
1	Title	Title
2	Program Options	Program Options
3	Physical Units	Roll Iteration
4	Hull Particulars	Seaway Description
5	Loading Particulars	Motions Points
6	Underwater Hull Geometry	Relative Motion Points
7	Sonar Dome	Ship Responses
8	Bilge Keel	Stop
9	Roll Stabilizer Fins	
10	Skeg	
11	Propeller Shafts	
12	Propeller Shaft Brackets	
13	Propellers	
14	Rudders	
15	Passive Stabilizers	
16	Sinkage and Trim	
17	Wave Profile	
18	Roll Damping Model*	
19	Stop	

\*This record set is not implemented.

**Table 3. Nominal Values of Fin Controller Coefficients**

<b>(I)</b>	<b>K(I)</b>	<b>A(I)</b>	<b>B(I)</b>
1	1.0	1.0	1.0
2	2.5	0.16	0.63
3	1.0	0.025	0.092

**Table 4. Constants for Single Amplitude Statistics**

<b>Single Amplitude Statistics</b>	<b>Factor</b>
Root mean square amplitude, RMS	1.00 $\sigma$
Average amplitude	1.25 $\sigma$
Average of highest 1/3 amplitudes, Significant	2.00 $\sigma$
Highest expected amplitude in 10 successive amplitudes	2.15 $\sigma$
Average of highest 1/10 amplitudes	2.55 $\sigma$
Highest expected amplitude in 30 successive amplitudes	2.61 $\sigma$
Highest expected amplitude in 50 successive amplitudes	2.80 $\sigma$
Highest expected amplitude in 100 successive amplitudes	3.03 $\sigma$
Highest expected amplitude in 200 successive amplitudes	3.25 $\sigma$
Highest expected amplitude in 1000 successive amplitudes	3.72 $\sigma$
Highest expected amplitude in 3000 successive amplitudes	4.00 $\sigma$

Definitions:

$\sigma$  = Statistical variance of time history.

N = Number of successive amplitudes.

CONSTANT =  $\sqrt{2} (\ln N)^{1/2}$ , where CONSTANT relates the RMS amplitude to the highest expected amplitude in N successive amplitudes.

NOTES:

1. The highest expected amplitude in N amplitudes is the most probable extreme value in N amplitudes. This value may be exceeded 63 percent of the time.

2. To obtain wave height or double amplitude statistics from RMS values, multiply single amplitude constants by 2.0.

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## **Appendix A Modifications to SMP95 to Improve Closure of Hull Bending and Shear Loads**

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### **Abstract**

*The code that served as the starting point for the development of SMP95 contained incomplete code for lateral loads. In the SMP95 development no attempt was made to complete or correct this lateral loads code, though it was known that the lateral loads computed by means of this code suffered from closure problems. During the course of the present work the vertical loads were also found to have closure problems that needed fixing. It was the intent in the work summarized here to re-investigate and fix all SMP95 load closure problems, though this goal was not quite attained. This document summarizes the nature of the resulting changes to the code and includes a description of some minor changes to the interpretation of the input and a list of the modules affected.*

### **Introduction**

Though the strip theory ship motions and loads results of Salvesen, Tuck and Faltinsen [A - 1] formed the basis for the "Standard Motions Program", SMP, the first version, SMP81 [A - 2], included no loads computations at all. Later, the omission was partially rectified by the inclusion of code for vertical plane loads in SMP84 [A - 3]. Somehow, the vertical loads computation in SMP84 acquired a bad reputation between the release of the code and the work described in Dalzell et al [A - 4] where it was shown that the results were at least as valid as those of the competition. At this point interest was revived in SMP loads computation, and in 1994 a little support was made available to attempt the inclusion of a lateral loads capability in SMP.

In the period between 1985 and 1994 there appeared several versions of SMP. For example, SMP87 and SMP91 included modifications made at NAVSEA for porting to VAX and UNIX machines. SMP91, produced by Meyers at DTMB was a complete port of SMP84 to PC's. At the time of the start of the inclusion of the lateral loads code the most advanced version at DTMB was that which was probably later called SMP93-PC [A - 5], and this was the version used as the baseline for the load modifications.

In the earlier versions load transfer functions were computed late in the program when irregular waves were involved. For use with the lifetime loads program developed by Sikora, et

al [A - 6], it was desirable to be able to write out load transfer function files at an earlier stage of the computation. Accordingly, the loads part of the program was re-organized to accomplish this. This re-organization facilitated the inclusion of the (purely potential flow) lateral loads theory of Salvesen et al [A - 1].

During the application of lateral load results from the resulting version of SMP to the estimation of lifetime lateral loads, serious closure errors were detected. The diagnostics suggested that the lack of closure was primarily due to the inclusion of appendage and viscous loads in the lateral motions computations—but not in the loads computations. Work was started on a cure for this problem, but the operation ran out of steam and money, and was abandoned in favor of other commitments late in 1994. The net result of this operation was an experimental, partially undocumented, version of SMP that was occasionally called SMP94X.

In 1995 the development of SMP95 was initiated. Among the objectives of this development was the consolidation of as many as possible of the embellishments of the various previous versions, the reorganization of the code to separate deterministic hydromechanics from irregular wave estimates and seakeeping assessment issues, and to improve maintainability of the code. Because the SMP94X code mentioned in the last paragraph appeared to contain the best assortment of embellishments, this code was adopted as the baseline. The net effect was that SMP95 contained all the basic loads code of earlier versions of SMP, warts and all.

During the development of SMP95 the loads code was tested only to the extent required to prove operability and reasonable correlation of vertical moments with those resulting from SMP84 and SMP94X. The intent in the work summarized here was to re-investigate, and if possible fix, the loads closure problems that had surfaced in 1994.

### **Baseline Loads Closure Check**

Because a floating ship is a free-free beam, the internal bending moments and shears must be zero at the ends of the ship. Following the basic decisions in Salvesen et al [A - 1], in all versions of SMP bending and shear loads at a section are derived from an integration of the sectional loads over the hull *forward* of the station in question. This means that the computed moments and shears will automatically be zero at the bow, and that, if the computation is closing

properly, the computed moments and shears should tend toward zero as the station of interest approaches the stern.

The tendency of moments and shears toward zero at the stern should be true for all the wave frequencies that are significant in the load transfer function and for all wave directions. Though it is the trends of the transfer functions that are at issue, a convenient and more compact overall measure of closure may be obtained by using the transfer functions to compute significant loads as a function of hull station. If these significant loads, plotted on hull station do not extrapolate to some value that is reasonably small at the stern it is a good indication that the underlying transfer function computations are not closing properly.

For the purposes of the closure investigation the CG-47 was assumed. The input data for the model described in Dalzell et al [A - 4] was available. This input data includes definitions of most appendages including bilge keels, rudders and skeg, but for some reason no shaft brackets. This input data was made up for SMP84 and thus the possible dome and propeller shaft appendage inputs of SMP95 were not included.

Three speeds for the ship of zero, 10 and 20 knots were assumed, as was a long crested irregular wave with significant height of 16.4 feet and modal period of 15 seconds. With these assumptions SMP95 was organized to produce significant load estimates for 20 stations of the 25 hull station definition, and programming was assembled to extract and plot sub-sets of the resulting data from the SMP95 ".oot" file.

The available version of SMP95 was denoted Version 11, released on 1 August 1996. This version, originally checked on a VMS system, was ported for the local PC using Watcom FORTRAN for DOS. The results of test problems on the PC reasonably checked with those originally obtained under VMS.

Figure A - 1 is the result of the baseline closure investigation for the significant vertical plane bending and shear loads. A bow ( $45^{\circ}$ ) wave direction was selected for the presentation. In each frame the results for the three ship speeds are shown. Note that the SMP convention is that loads may be computed only for points that are mid-way between hull stations. Thus the points shown are on half stations near midship. At the stern, the next to last station is 19.75 so that the

last load computation is for station 19.875.

The results shown in Figure A - 1 were a major surprise. It was concluded on the basis of a much less intensive check in Dalzell et al [A - 4] that the vertical moments computed by SMP84 closed adequately, and it was assumed that the present results would confirm this earlier conclusion. Figure A - 1 indicates that the vertical moment closure error exceeds 10% of the midship moment! Perhaps it depends upon the definition of "adequately", but the evidence in Figure A - 1 suggests that the vertical moments really do not close well. The closure of vertical shear actually looks worse.

The guts of the code for vertical moment and shears were investigated in SMP91, SMP87 and SMP84 with the conclusion that no technical changes had occurred since the first incorporation of loads into SMP. The implication is that vertical loads from SMP have always had a closure problem that is big enough to notice in a determined investigation, but not enough to badly distort correlation studies that tend to concentrate on midship loads.

Figure A - 2 is the corresponding result of the baseline closure investigation for the significant lateral plane loads. The three frames show horizontal moments and shears and torsional moment. As expected, the moment closure errors are a quite significant fraction of midship horizontal and torsional moments, as are the at-speed shear errors.

The magnitude of the closure errors shown in Figure A - 1 and Figure A - 2 were verified approximately by plotting the load transfer functions for several stations in the after part of the ship.

### **SMP95, Version 11a**

A number of code changes were made in order to reduce the closure problems. The resulting version of SMP95 is called Version 11a in order to emphasize the fact that the baseline for the current work was Version 11 (it is understood that there have been a number of increments to the version number since 1996). Here, the nature of the changes is outlined. A changed module list will appear later.

## Modifications to input conventions and defaults

There is no change in the input, only in the interpretation of some input and in some defaults.

SMP95 Record set 6F includes the definition of the ship weight distribution. The corresponding excerpt from the SMP95 Version 11 input instructions is presented in Table A - 1.

**Table A - 1. Excerpt from SMP95 Input Instructions, Record Set 6F**

. . . .

If NLOADS is greater than 0 then the following record is repeated NSTATN times to define the ship weight distribution.

RECORD SET 6F

STATN, SWGHT, SKG, SKROLL, SKPITCH, SKYAW (6F10.2)

where

STATN= the station number. Stations for this section of the input must be exactly the same stations as for the definitions of the hull offsets.

SWGHT= a lumped weight which represents an apportionment of the weight curve to STATN. Note that the weight is expected to be in long tons (force) if PUNITS="FEET", or metric tons (mass unit) if PUNITS="METER".

SKG= vertical location of the center of gravity of the weight apportioned to the station, feet or meters, positive above the baseline.

SKROLL= the roll gyradius of the weight apportioned to the station, feet or meters.

SKPITCH= the pitch gyradius of the weight apportioned to the station, feet or meters.

SKYAW= the yaw gyradius of the weight apportioned to the station, feet or meters.

. . . .

The convention that the lumped weight representation of the ship must include a lumped weight at each and every hull station was established in SMP84 and was implied in Salvesen et al [A - 1]. It is not a terribly convenient convention because weights are seldom estimated in lumps that are coincident with stations. Moreover, the assumption that each lump was a point mass in the pitch and yaw directions often made it very difficult to make an input weight

distribution for SMP from design estimates without the extra degrees of freedom that the gyradii of the lumps would provide. Accordingly, pitch and yaw gyradii of each lump were provided for in the SMP95 input, but not actually used in Version 11. The change made for Version 11a was to use these gyradii for the load computation. Because of the way that SMP handles null input fields it is not necessary to define the pitch and yaw gyradii of the lumped weights if they are actually zero.

Note that it is assumed that the center of gravity of each lump is at the defining station at the given vertical position and in the ship centerplane. It is also assumed that the three gyradii of each lumped weight are with respect to its center of gravity. Finally, a further assumption is that all the products of inertia of each of the lumped weights are zero or negligible.

The data in Record Set 6F defines the "weight ship". Immediately after the input is read in Version 11a, the totals for the "weight ship" are computed and written in the output file. The computation includes the total weight (or mass), the longitudinal and vertical centers of gravity (LCB, KG), the roll, pitch and yaw gyradii, and the roll-yaw product of inertia divided by the ship mass. The gyradii and the product of inertia are computed relative to the ship center of gravity.

In Version 11, the data contained in the weight distribution is used *only* in the computation of the load transfer functions, while the total mass, the centers and the inertias used in the motions computation are from the hydrostatic computations and the overall centers and gyradii given in Record Set 5. Thus, as far as mass distribution effects are concerned it is possible to specify entirely different "hydrodynamic" and "weight" ships—which would guarantee serious closure errors.

Accordingly, Version 11a contains some revised philosophy, which is that if loads are to be computed, the vertical center and the gyradii in Record Set 5 are to be *replaced* by values for the ship derived from the input weight distribution. In detail, if loads are to be computed, the input definition of KG is replaced by the value computed from the weight distribution. The delta KG for free surface is ignored—in any event this feature of SMP does not appear to do anything but modify the Record Set 5 KG. Additionally, if loads are to be computed, the Record Set 5 values

of roll, pitch and yaw gyradii are replaced by the values computed from the integration of the weight distribution. Note that while the Record Set 5 roll gyradius is supposed to be relative to the cg, the input pitch gyradius is to be about a point in the waterplane and at the LCG; the values from the weight distribution computation are corrected accordingly. Normally the roll-yaw product of inertia of the ship is defaulted to zero. If loads are to be computed, the roll-yaw product of inertia is defined from the weight distribution integration.

As in Version 11, the user must insure that the total specified weight is close to the displacement computed for the specified draft and trim and that the LCG from the input weight distribution is close to the LCB from the hydrostatic computation. Accordingly, in Version 11a, once the hydrostatics are complete, the weight and displacement and the LCB and LCG are compared. It is assumed that the two measures of weight are sufficiently close if they differ by less than 0.5%. Similarly, it is assumed that LCB and LCG are sufficiently close if they differ by less than 0.5% of ship length. If either or both of these criteria are not satisfied, a fatal error occurs—the offending numbers are printed in the log and output files and the execution is terminated.

SMP95 Record set 6G includes the definition of the longitudinal locations where loads are to be computed. The corresponding excerpt from the SMP95 Version 11 input instructions is presented in Table A - 2.

**Table A - 2. Excerpt from SMP95 Input Instructions, Record Set 6G**

```

. . .
RECORD SET 6G - Required if NLOADS>0
      (XLDSTN(K),K=1,NLOADS) (8F10.4)
where
XLDSTN = the station numbers at which loads are to be calculated.
      Note that the specified station numbers must correspond exactly
      to one of the station numbers specified earlier.
. . .

```

It has been noted that the actual locations for which SMP computes loads are midway between the specified station and the next higher one. Though it is not a serious problem, the code does not bear out the Note in Table A - 2. It appears to the writer that if the specified station



falls between two hull stations, the load location will still be midway between the stations.

An exception has been included in Version 11a. For purposes of checking closure, modifications were made to the code to allow the last specified load station to correspond to the last hull station (station 20). In this case the location of the load computation is at the last hull station. When this condition is detected, a notice is written in the log file that a closure check station is included in the run.

Because the input weight distribution used for the CG-47 was already pretty well aligned with the overall displacement, centers and gyradii these changes made very little change to the closure problems evident in the example, Figure A - 1 and Figure A - 2.

### **The Salvesen, Tuck and Faltinsen end terms**

The hydrodynamic theory of Salvesen et al [A - 1] included what were called "end terms". There was argument about the practical validity of these terms from the outset. In the documentation of the motions programming of SMP81 [A - 2] it is plainly stated that the theory is that of Salvesen, Tuck and Faltinsen *without the end terms*. As is borne out by an examination of the code, this decision carried through to SMP95. An examination of the loads code in Version 11 disclosed that the code reflected the loads formulae of Salvesen et al *including the end terms*.

The Salvesen-Tuck-Faltinsen formulae for the shears and the torsional moment all include end terms. Besides being a simple programming error, this end term inconsistency is clearly a potential source of lack of closure in the shears and torsional moments. The end term code in Version 11 was eliminated in Version 11a. The result was an improvement in closure of shears and the torsional moment though it was evident that there were other problems.

### **Vertical plane load corrections**

In all versions of SMP the vertical and lateral plane motions are computed separately. Possibly for this reason, any possible vertical plane appendage forces are neglected. The effect is that the vertical moment and shear loads are completely unaffected by the presence or absence of appendages, or by the semi-empirical viscous computations which contribute to roll damping.

The vertical load closure problem is purely one involving consistency of rigid body dynamics and potential flow.

A review of the consistency of the motions and loads computations in all parts of the vertical plane problem disclosed two additional inconsistencies. Both involve the programming of the load side to conform to the formulae of Salvesen et al [A - 1] without compensating for alterations made to the motions side of the Salvesen-Tuck-Faltinsen theory by the SMP developers.

While Salvesen, Tuck and Faltinsen developed their expressions for loads for a 5-degree of freedom system (neglecting surge), the SMP programmers included the surge degree of freedom (in an incomplete way). The effect was that the surge and pitch equations were inertially coupled, and this in turn meant that for consistency a surge dependent coupling term had to be added to the expression for the vertical moment load.

Similarly, Salvesen, Tuck and Faltinsen approximated the pitch restoring coefficient as the product of the weight density of water and the longitudinal inertia of the waterplane, while the SMP programmers used the product of displacement and longitudinal metacentric height. To achieve consistency in this respect, terms involving VCB and VCG were added to the vertical load expression from Salvesen, Tuck and Faltinsen to compensate for the difference.

These corrections, along with the elimination of the end term coding appear to reduce the vertical moment and shear closure errors to an acceptable level.

### **Lateral plane load corrections: rigid body and potential flow**

With the inconsistencies discovered in the purely rigid body and potential flow vertical plane loads, it was thought prudent to pursue the possibility of similar problems in the lateral plane loads. Fortunately, the SMP95 programming is such that it is straight forward to disable all considerations of appendages and viscous flow approximations, and consider the lateral plane motions and loads as a purely rigid body and potential flow problem.

With the appendage effects suppressed, the lateral moment appeared still to have enough of a closure problem to be of concern, the lateral shear closure error seemed at an acceptable level,

and the torsional moment closure problem was small, but visible.

In the roll restoring component of the torsional moment computation of Version 11 the coding combines terms involving the sectional vertical center of gravity and the sectional center of buoyancy into a single lumped approximation to apply at each hull station. It was found that the closure error of the torsional moment was reduced to an acceptable level if the essentially hydrostatic part of the restoration problem was treated as a numerical integration, and the vertical center of gravity part as a lumped approximation centered at each hull station. The change is essentially one of integration method rather than one involving fundamental inconsistencies.

Despite a good deal of analysis of the decomposition of the lateral moments into sectional contributions, and quite a number of numerical experiments to diagnose the problem, the lack of good lateral moment closure could not be fixed. From an examination of the transfer functions it appears that there is some inconsistency involving the coupling from roll. This points to an inconsistency in the hydrodynamic components of the lateral moment. It may well be purely numerical since without appendage damping the roll angles are quite large.

Figure A - 3 shows the closure chart for lateral moment and shear and torsional moment that was obtained when all appendage code was suppressed and the CG47 was stripped of all appendages for good measure. The significant moments for shears and torsional moments tend uniformly toward zero at Station 20 as hoped, but those for horizontal bending moments do not. The best that can be said is that the closure appears somewhat better than that displayed in the corresponding baseline chart, Figure A - 2.

### **Lateral plane load corrections: appendages, active fins, stabilizers**

In order to compute the effects of appendages on loads, the total forces and moments produced by the appendages must be transformed into sectional load components that may be partially integrated to produce the total effect of appendages on the loads at a specified longitudinal position. Looked at the other way, in order that the computations close, the integration over the entire hull of the sectional load components for torsional moment and lateral shear must equal the appendage contributions to the roll moment and sway force on the ship. Integration of the sectional lateral moment components over the entire hull must equal the sum

of the appendage contributions to yaw moment about the LCG and a moment of transference of the appendage sway force to the aft end of the ship.

The Version 11 code contained what appeared to be tentative beginnings of code to achieve these goals. This code was used as an initial guide. However, the final code was philosophically different in detail and thus is nearly all new.

The most important appendages are relatively concentrated in the longitudinal direction. Thus, for purposes of computing loads, it appeared that a reasonable approximation to the sectional forces and moments from appendages would involve concentrated forces and moments on appropriate discrete stations (just as the weight distribution is concentrated on stations). Because the specified load locations can only be midway between stations, under this scheme the computation of the influence of the appendages on the total loads from this lumped approximation amounts only to partial summations of the lumped appendage forces and moments for stations forward of the specified load position.

Within SMP, forces and moments due to "appendages" include lift, eddy making and skin friction forces and moments on the hull in addition to like quantities on real appendages such as skegs, shaft brackets, fins and bilge keels. Because the effects of the hull are usually relatively small, it was assumed a reasonable approximation to distribute the hull contributions uniformly over the hull length. With less of a stretch the contributions of the other appendages were distributed over near stations. The mechanics involve a simple subroutine that returns a weighting number for each hull station given the longitudinal extent of the appendage. The sum of the weighting numbers is unity so that the total of the weighted forces and moments are the same as the total computed for the ship.

In the Version 11 code, all the linear effects of appendages upon the lateral equations of motion are computed in one of two subroutines that differ very little. In either case the routine increments each term in the complex 3 by 3 left hand sides of the lateral plane equations, and each of the three complex excitations. At this point in the computation the roll moments are about the vertical center of gravity. In order to ultimately compute loads about the waterplane, the complex increments due to each appendage are transformed from the vertical cg to the

waterplane. Finally, the transformed complex increments are weighted and these weighted results are accumulated in two holding arrays that are ultimately passed to the module where the loads are computed.

Each of the appendages contributes to a value of the nonlinear roll damping coefficient. The total of the contributions of all appendages is passed to the main motions computation module and inserted into the equations of motion before their solution. The nonlinear contributions for the load computation are handled similarly to the linear contributions. At the conclusion of the computation for each appendage, its contribution to the total is weighted according to the longitudinal extent of the appendage and accumulated in a third holding array that ultimately finds its way to the load computation module.

The active fin code produces linearized increments to the complex coefficients of roll in the three equations of motion. As before, these increments are relative to an origin at the vertical center of gravity, and accordingly, they are transformed to an origin at the waterline before weighting in accordance with the fin location and accumulated in a fourth holding array against the load computation.

When passive stabilizers are specified, each contributes an additional degree of freedom to the lateral motions system, as well as additional excitations to the sway, roll and yaw equations. Once the stabilized system is solved and values of the stabilizer transfer are known the computation of the force and moment increments to the equations of motions may be made. These are weighted in accordance with the longitudinal location of the stabilizer and the weighted increments are accumulated in a fifth array against the later load computation.

### **Closure Demonstration, Version 11a**

Figure A - 4 is the result of the re-running the baseline closure investigation on Version 11a for the significant vertical plane bending and shear loads. As in Figure A - 1, a bow (45°) wave direction was selected for the presentation. In each frame the results for the three ship speeds are shown. In these runs advantage was taken of the Version 11a modification that allows the specification of Station 20 as a load station. The moments near midship are not changed much from those shown in Figure A - 1. As desired, the moments at the aft end of the ship tend quite

well to a very small fraction of midship moment. The vertical shears also tend quite well to zero at the aft end of the ship. Note by comparing the results with those in Figure A - 1 that the code modifications have produced some change in the magnitude of the vertical shears.

Figure A - 5 is the corresponding result of re-running the baseline closure investigation on Version 11a for the significant lateral plane loads. The three frames show horizontal moments and shears and torsional moment. As desired, the moments at the ends of the ship are much closer to zero than was true at the outset, Figure A - 2. When the contributions of the appendages are taken into account the horizontal moment closure is better than that shown for the hull-only case, Figure A - 3. The lateral shear closure is quite good as a percent of the shear magnitude near the quarter points, that of the torsion is slightly less good.

### **Module List**

SMP95 Version 11a differs from Version 11 in a total of 19 files, six of which are new.

Two common blocks are changed. The contents of the APPLOADS block are radically changed from the original.

LOADS .CMN

APPLOADS .CMN

Ten of the files in the SMP95 regular wave program (SMPREGW) are modified in some way. The files are:

ACTFIN .FOR

EQMOTN .FOR

HSTAT .FOR

LSCOF .FOR

LSCOF .FOR

LTFN .FOR

PSTAB04 .FOR

RDEVAL .FOR

READ.FOR

SINKTRIM.FOR

The major changes are in LTFN, which is the module that computes load transfer functions. As far as executable code is concerned, EQMOTN is not changed, but a number of comments, and one commented out debugging sequence have been added. The (trivial) modification to SINKTRIM is to remove a redundant specification. The other files contain relatively moderate changes in accordance with the descriptions noted earlier.

The six new modules all contribute to the accumulation of forces and moments due to the various appendages. They are:

APPLD0.FOR

APPLD1.FOR

APPLD2.FOR

APPLD3.FOR

APPLD4.FOR

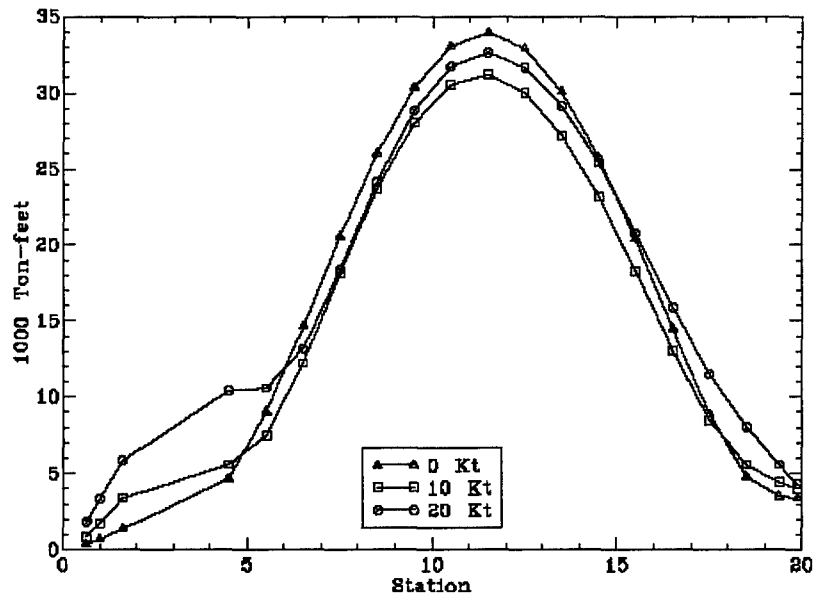
APPLD5.FOR

Finally, one of the modules from the irregular part of SMP95 (SMPIRGW) needs a small correction to allow vertical moments and shears to be computed for head and following waves.

RAOPHS.FOR

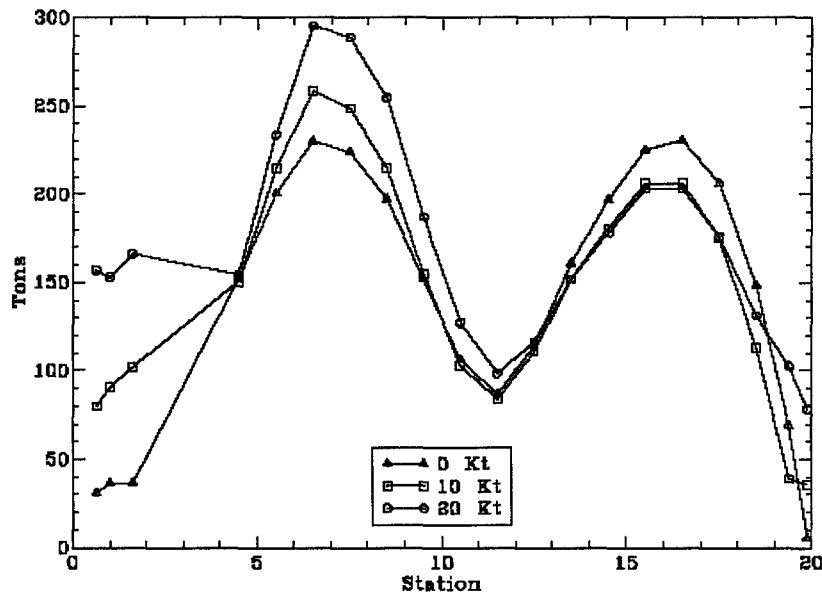
SMP95 version 11, original CG47MODL input file.

CG-47,  $H_s = 16.4$  ft,  $T_p = 15$  sec, Heading 45 deg



Significant Vertical Bending Moment

CG-47,  $H_s = 16.4$  ft,  $T_p = 15$  sec, Heading 45 deg



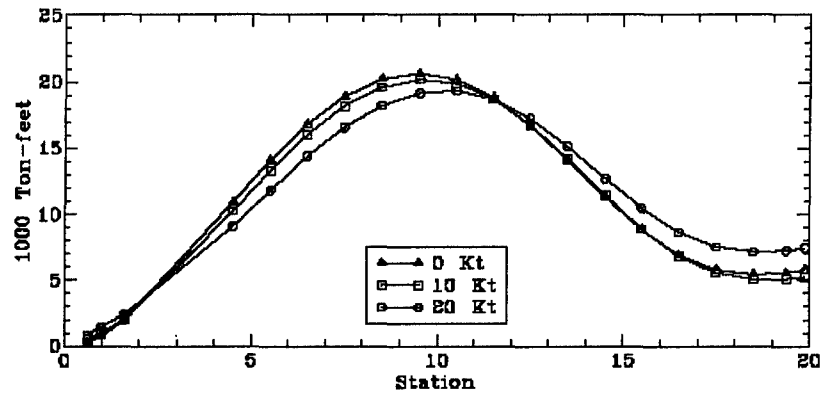
Significant Vertical Shear

Figure A - 1. Baseline closure check, vertical loads, CG 47 in bow waves



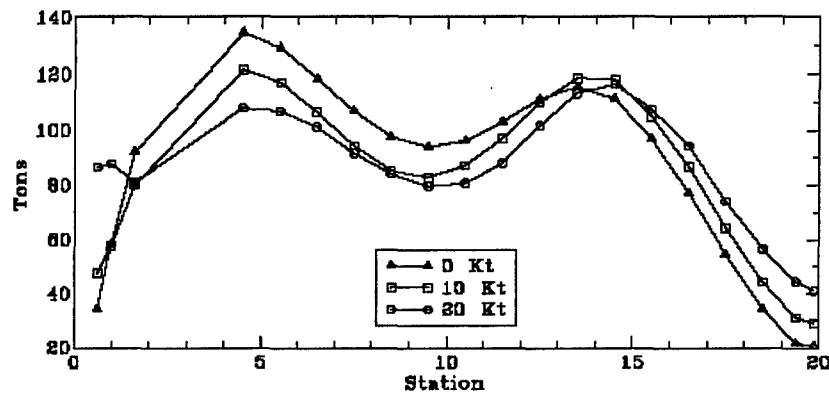
SMP95 version 11, original CG47MODL input file.

CG-47,  $H_s = 16.4$  ft,  $T_p = 15$  sec, Heading 45 deg



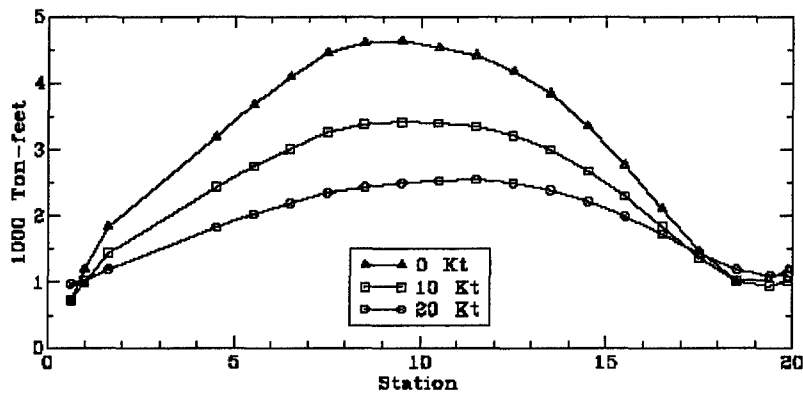
Significant Horizontal Bending Moment

CG-47,  $H_s = 16.4$  ft,  $T_p = 15$  sec, Heading 45 deg



Significant Horizontal Shear

CG-47,  $H_s = 16.4$  ft,  $T_p = 15$  sec, Heading 45 deg

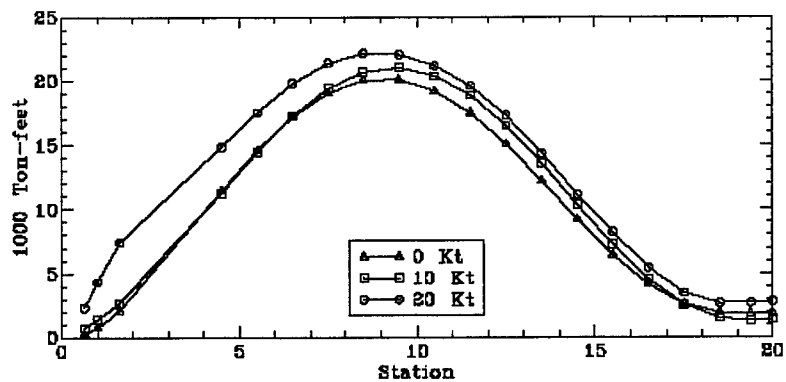


Significant Torsional Moment

Figure A - 2. Baseline closure check, lateral loads, CG 47 in bow waves

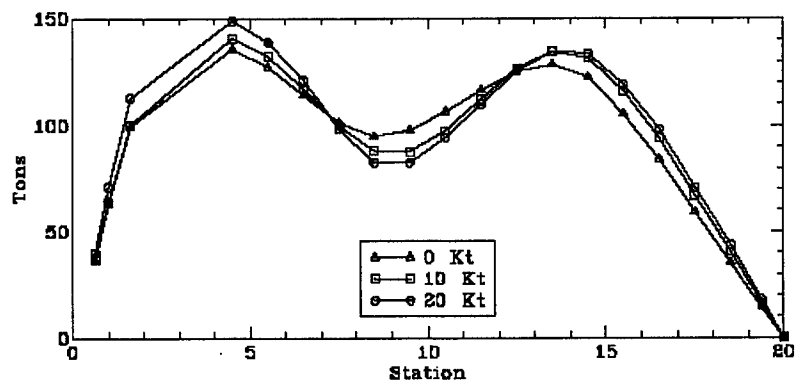
SMP95, V11a, appendage code suppressed, CG47 w/o appendages

CG-47,  $H_s = 16.4$  ft,  $T_0 = 15$  sec, Heading 45 deg



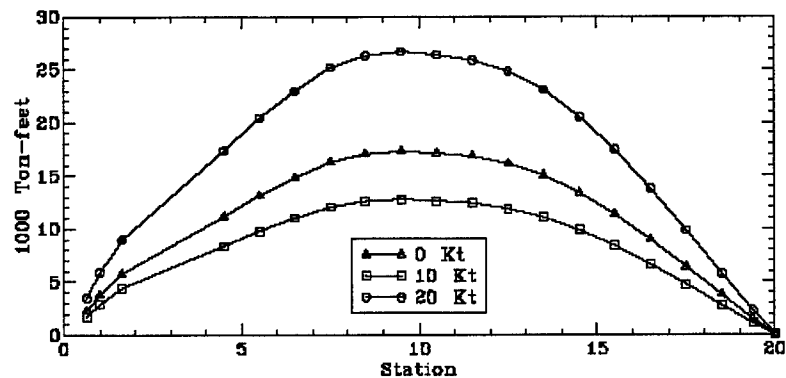
Significant Horizontal Bending Moment

CG-47,  $H_s = 16.4$  ft,  $T_0 = 15$  sec, Heading 45 deg



Significant Horizontal Shear

CG-47,  $H_s = 16.4$  ft,  $T_0 = 15$  sec, Heading 45 deg

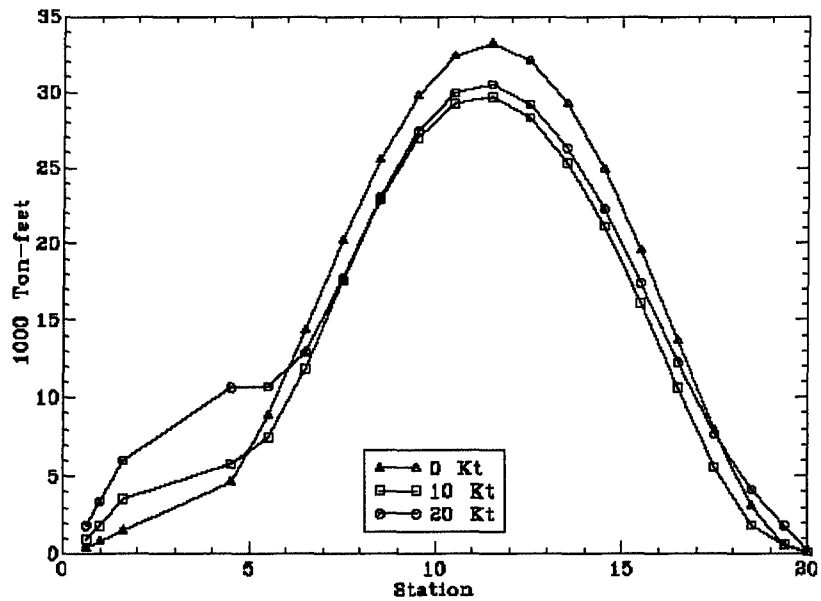


Significant Torsional Moment

Figure A - 3. Closure check, lateral loads, version 11a with appendage code suppressed, CG 47 without appendages in bow waves

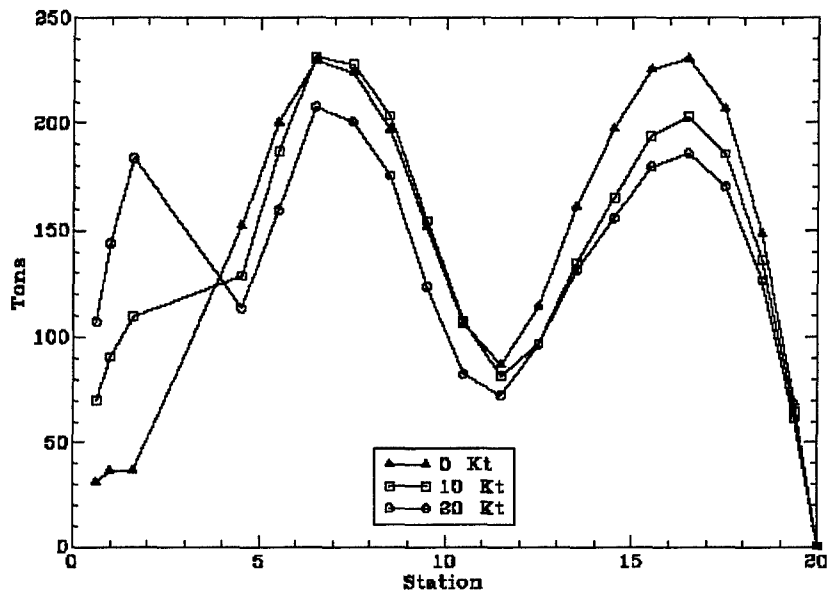
SMP95, Version 11a, CG47MODL input file

CG-47,  $H_s = 16.4$  ft,  $T_0 = 15$  sec, Heading 45 deg



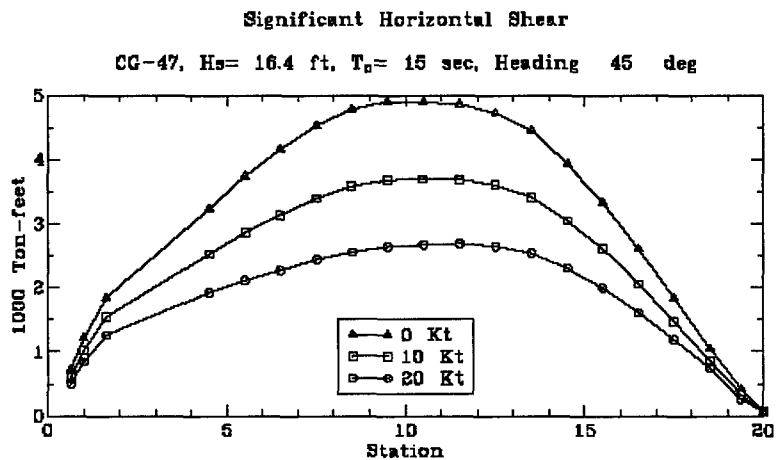
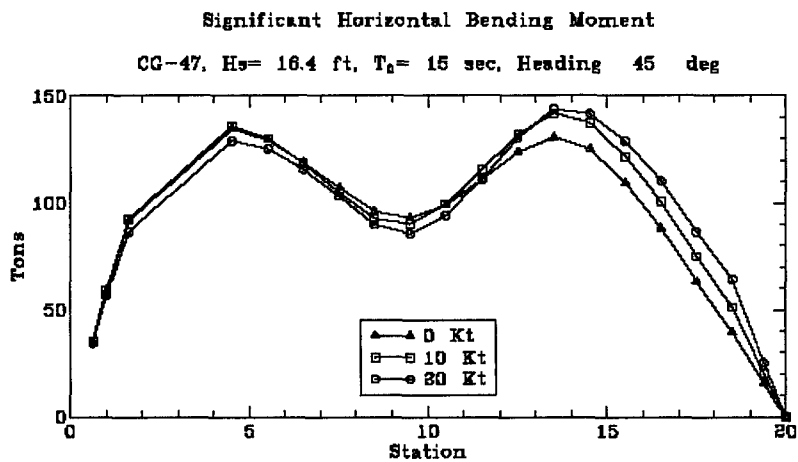
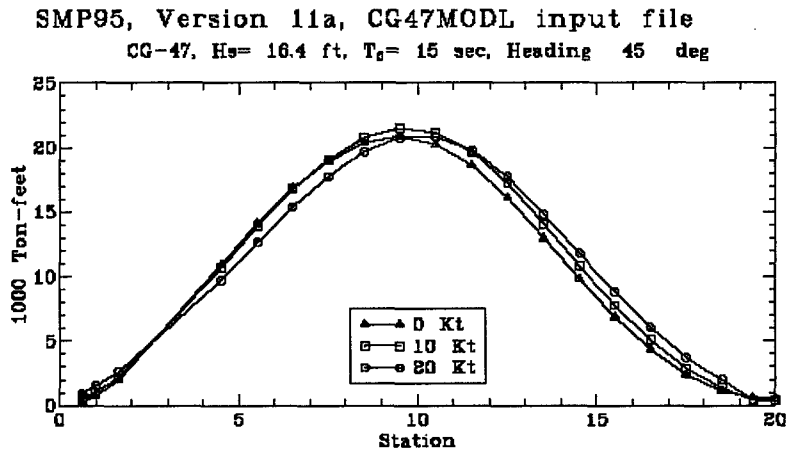
Significant Vertical Bending Moment

CG-47,  $H_s = 16.4$  ft,  $T_0 = 15$  sec, Heading 45 deg



Significant Vertical Shear

Figure A - 4. Final closure check, vertical loads, CG 47 in bow waves



Significant Torsional Moment

Figure A - 5. Final closure check, lateral loads, CG 47 in bow waves

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## **Appendix B SMP95 Passive Stabilizer Option**

John F. Dalzell

### **Objective**

The objective of the passive stabilizer option in SMP95 is to enable some approximate estimates of the worth, or otherwise, of passive ship stabilization. The caveat arises because even the simplified practical models of the dynamics of the most used tank stabilizer types contain two types of (not entirely negligible) nonlinearities. The first, type of nonlinearity is "quadratic" tank damping. The second type is that of the eventual saturation of the roll moment generation capability for large tank excitations. These nonlinearities have to be handled in an approximate way within the limitations imposed by the linearized frequency domain method of SMP.

### **Range of Stabilizer Types**

The analytical models of both common forms of passive tanks, as well as that of a moving weight stabilizer, are ultimately of identical form. Consequently, as long as some variation in the definition of the input parameters are allowed, the same basic code can serve to represent the effects of U-tube tanks, Free-surface tanks, and moving weight stabilizers.

### **Approach to the Hydromechanical Solution**

The way in which SMP handles the basic ship roll nonlinearities determines to a great degree how the passive stabilizer solution is handled. The basic SMP theory holds that the ship roll nonlinearities are purely a function of roll amplitude. Given this assumption, the SMP way is to linearize the lateral motion solution for each of a number of assumed roll amplitudes, thus producing a number of sets of lateral motion transfer functions, each of which is associated with the assumed roll amplitude. Predictions of lateral motions in irregular seas are made by an interpolation procedure where the interpolation point is determined by an equality of interpolated assumed roll amplitudes with interpolated significant roll amplitudes which are predicted from the corresponding set of linearized transfer functions.

The present approach to the solution of the coupled nonlinear ship-stabilizer dynamics is conceptually similar to that adopted for free flooding tanks some years ago [B - 1]. Each combination of ship speed, heading, assumed roll angle and wave frequency defines a



deterministic problem, which may be handled in the frequency domain. Each frequency domain solution for a point of the stabilized roll transfer function is made iteratively in two stages, the first to obtain a solution for an unsaturated stabilizer, and the second to correct for the effects of saturation.

At the start of each iteration for the unsaturated stabilizer an estimate of the roll and stabilizer transfer functions are in hand, either by guessing, or from previous iterations. The fact that a fixed, constant, roll amplitude was assumed in the first place allows an implied wave amplitude to be computed. With an implied wave amplitude and the estimate of the tank motion transfer function, an estimate of stabilizer amplitude may be obtained. With the stabilizer amplitude, the nonlinearities may be evaluated and linearized to complete the specification of a linearized coupled ship-stabilizer problem that has one extra degree of freedom for each stabilizer. Solution of the coupled problem yields revised estimates of roll and stabilizer transfer functions, which are used to begin the iterations again, unless the solutions differ from the initial assumptions by a small enough amount to ignore.

Once a reasonably good solution is obtained for the unsaturated case, the implied wave amplitude is used to compute the stabilizer motion, and the answer is compared with the specified saturation limits. If the stabilizer motion is not within the specified saturation limits, a second iteration, generally similar to the first, is carried out. In this second iteration the stabilizer amplitudes exceeding the saturation limit are limited to a reasonable level by a conventional energy argument. Once stabilizer amplitude is limited, the solution for the stabilizer transfer function is known. With a known stabilizer solution, the saturated stabilizer degree of freedom is dropped from the coupled ship-stabilizer problem, and the corresponding stabilizer coupling terms formerly on the left hand side of the system of linearized motion equations are transposed to the right hand side to correct the motion excitation, for the effects of the saturated stabilizer.

It should be noted that this approach to the production of stabilized roll transfer functions involves approximating the nonlinear solutions to a physical problem where the amplitude of the exciting regular wave is *adjusted* so as to produce a stabilized roll amplitude which is essentially equal to that assumed. Though it fits with the SMP way of doing things, the result for a single assumed roll amplitude is not the same as would be obtained from a physical regular wave test,

and in fact, to compare computed results directly with regular wave test results requires an interpolation procedure similar to that adopted by SMP for irregular waves.

### Irregular Wave Predictions

Once the hydromechanical problem is solved, the resulting lateral motion transfer functions are stored and used in exactly the same way as in the unstabilized case. Consequently, apart from the fact that the transfer functions, and answers, will be different from the unstabilized case, none of the downstream SMP processing for motions in irregular waves is affected by the presence of stabilizers.

A by-product of the solution is a set of stabilizer motion transfer functions for the unsaturated case. The only really useful thing that can be done with these results is to predict the number of saturations per unit time. This operation is carried out in the irregular wave half of SMP95, and the results are listed for the most saturated stabilizer in the more-or less standard SMP way for slamming or deck wetness incidence. The saturation incidence results are listed automatically as long as the user does not suppress the listings of the basic ship motion responses.

### Tank Stabilizers

As has been noted, the basic equations are identical for the two common types of tank stabilizers. The equation for either type of stabilizer ends up in the program in the following form:

$$\rho\gamma I_W \ddot{\xi}_2 + \rho\gamma I_W [g\xi_4 - l\ddot{\xi}_4] + \rho\gamma I_W \ddot{X}\xi_6 + \frac{\rho\gamma g I_W}{R} \left[ \frac{\ddot{\xi}_7}{\omega_t^2} + \xi_7 \right] + \frac{2\rho\gamma g I_W}{R\omega_t} \beta_L \dot{\xi}_7 + \frac{\rho\gamma I_W}{R} \beta_Q |\dot{\xi}_7| \dot{\xi}_7 = 0 \quad (1)$$

where the first three terms are the transposed excitation to the tank and:

- $\xi_2$  is the sway motion,
- $\xi_4$  is the roll motion,
- $\xi_6$  is the yaw motion, and

- $\xi_7$  is the tank fluid motion measure. Tank motion is defined as a vertical motion of the tank free surface in a wing tank. The exact lateral location is defined by the parameter  $R$ .
- $R$  is the lateral offset of the location of the "measurement" of  $\xi_7$ .
- $\rho\gamma$  represents the mass density of the fluid in the tank, in terms of  $\rho$ , the mass density of the water, in which the ship floats, and  $\gamma$ , a specific gravity of the fluid in the tank relative to  $\rho$ .
- $g$  is the gravitational constant.
- $I_w$  is the transverse inertia about the ship centerplane of the tank waterplane area,
- $X$  is the longitudinal location of the tank with respect to the ship longitudinal center of gravity.
- $l$  is the effective vertical location of the tank relative to the ship vertical center of gravity.
- $\omega_t$  is the tank natural frequency (rad/sec).
- $\beta_L$  is a nondimensional linear damping coefficient,
- $\beta_Q$  is a nondimensional quadratic damping coefficient.

Equation 1 expresses the moment response of the tank in response to moment excitation produced by the motion of the ship. As defined above, the units of each of the terms in Equation 1 are moments (about the center of gravity of the ship). Within the program, all the motions are implicitly divided by wave amplitude because of the necessity of computing transfer functions, and the actual equation within the program has units of force.

Unfortunately, the fluid dynamics internal to the tank are sufficiently complicated that, for serious design, the tank frequency and damping coefficients,  $\omega_t$ ,  $\beta_L$ , and  $\beta_Q$ , are regarded as empirical parameters which must be obtained from bench tests of model tanks.

The tank frequency,  $\omega_t$  is taken from bench tests as the frequency of peak tank motion

response for very small excitation, or, as the frequency at which the moment response of the tank lags motion by  $90^\circ$ .

The definition of the damping coefficients may be better illustrated by writing the equation for the tank dynamics after an impulsive excitation (a viable experimental approach for U-tubes at least). Zeroing the first three excitation terms of Equation 1, and eliminating common factors results in an equation for  $\xi_7$ , partially in the standard form of a simple oscillator:

$$\ddot{\xi}_7 + \omega_t^2 \xi_7 + 2\omega_t \beta_L \dot{\xi}_7 + \frac{\omega_t^2}{g} \beta_Q |\dot{\xi}_7| \dot{\xi}_7 = 0 \quad (2)$$

From Equation 2 the coefficients of the linear damping of the tank motion immediately identify  $\beta_L$  as a fraction of critical damping. Similarly, the non-dimensional quadratic damping of the tank motion,  $\beta_Q$ , would be a fitted empirical dimensional coefficient (units of 1/length) times  $g/\omega_t^2$ .

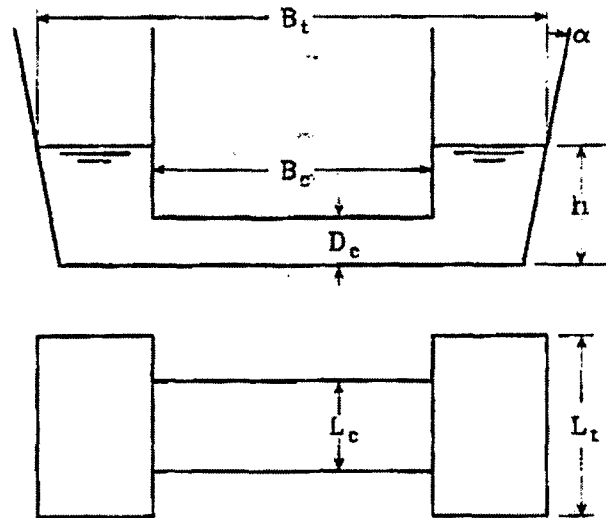
### Particular Input Parameter Definitions, U-Tube Stabilizer

The detail and form of the general equation for the tank, Equation 1 owes much to the early work of Webster [B - 2] [B - 3] for U-tubes. Equation 1 is essentially that of Webster, after compensating for the fact that the SMP coordinate system has the Z-axis positive up instead of down, and transforming Webster's "tank angle",  $\tau$ , to vertical motion at the wing tank center by  $\xi_7 = R\tau$ . A few of the parameters defined for Equation 1 has special definitions for the U-tube as follows:

- $I_W$  is conventionally taken to be  $2 A_O R^2$  where  $A_O$  is the area of the free surface in one wing tank.
- $l$  is half the classical coupling length,  $S''$ , defined for example by Webster [B - 3]. That is, in Equation 1,  $l = S''/2$ .
- $\omega_t$  is defined by  $\omega_t = \sqrt{2g/S'}$ , where  $S'$  is the classical effective U-tube length [B - 3].

### Some Approximations for U-Tube Tank Input

On the premise that first approximations may be useful, and/or, that no bench test results are available for a U-tube tank similar to a candidate U-tube geometry, a pre-processor program named UTTANK was developed to ease the production of preliminary U-tube input to SMP95. Such a thing is possible only for simplified tank geometry. The simplified geometry assumed is indicated in Figure B - 1 where the upper diagram is of a thwartship section through the tank and the lower is the planform.



**Figure B - 1. Terminology, Simplified U-tube Tank**

As shown in Figure B - 1, the simplified geometry involves a rectangular crossover duct  $B_c$  in length,  $D_c$  in height and  $L_c$  in width. The wing tanks, of width  $L_t$  (fore and aft direction), are allowed to flare  $\alpha$  degrees, and the overall thwartship tank length,  $B_t$ , is reckoned to the intersections of the static waterline with the outboard sides of the wing tanks. The static water depth is denoted by  $h$ .

With the geometry shown in Figure B - 1:

$$A_0 = L_t (B_t - B_c) / 2$$

$$R = (B_t + B_c) / 4$$

$$S' \approx \frac{A_0 B_c}{D_c L_c} + 2h \left[ \frac{-\ln \left\{ 1 - \frac{2h}{(B_t - B_c)} \tan(\alpha) \right\}}{\frac{2h}{(B_t - B_c)} \tan(\alpha)} \right]$$

$$\ell = S''/2 \approx Z_0 + h - (h - D_c/2) \left[ 2 - \frac{(h - D_c/2)}{R} \tan(\alpha/2) \right] - \overline{KG}$$

where  $Z_0$  is the distance from keel to the tank bottom, and  $KG$  is the ship vertical center of gravity.

With the previous definitions of geometric parameters and tank frequency, the above leaves the nondimensional damping coefficients,  $\beta_L$ , and  $\beta_Q$  to be defined. The UTTANK program allows entry of independently determined values as well as a default selection.

The default selection to be outlined has not been widely correlated with experiment, at least not in published form, though it is known to have provided reasonable results. It is based upon the early work of Webster [B - 4], and results in damping which is entirely quadratic. Bench tests of U-tubes often produce some non-negligible linear damping, as well as the expected quadratic damping. Since an average estimate of the linear damping in U-tubes is not known, the UTTANK program arbitrarily sets  $\beta_L$  to a small value-1% of critical.

The approach to the quadratic damping coefficient involves the approximation of the pressure head losses through the crossover duct as though the flow were steady. In particular, the head loss through the simplified duct is represented in the form:

$$H_c = (\sum_k C'_{lk}) [A_0 / D_c L_c]^2 (\xi_7)^2 / 2g = C_l (\xi_7)^2 / 2g$$

where the sum over the loss coefficients,  $C_{lk}$ , pertains to the multiple mechanisms that may contribute to the head loss. The various loss coefficients,  $C'_{lk}$ , are assumed to be estimated relative to the mean velocity in the duct. The squared  $A_0 / (D_c L_c)$  factor is to correct the reference velocity to that of the fluid at the free surface of the wing tank.

$$C_l = \left( \sum_k C'_{lk} \right) \left[ \frac{A_0}{D_c L_c} \right]^2$$

is termed the total head loss coefficient. Comparing Equation 1 with the corresponding

derivation in Webster [B - 2], the nondimensional quadratic damping coefficient required for SMP95 input is found to be

$$\beta_q = C_t/4$$

The default damping estimates are considered to be from three sources,

1. Estimated loss coefficient due to friction in the duct,  $C'_{11}$ . Friction in the duct is estimated from an approximate representation of Moody high Reynolds Number fully turbulent pipe friction factors, a roughness of 0.002 feet or 0.0006 meters, and the length and hydraulic radius of the crossover duct. (Friction is ordinarily not the controlling part of the total loss coefficient for tanks of the present type, and accordingly, no great care has been taken with this part of the estimate.)
2. Sudden expansion and contraction losses together produce a loss coefficient,  $C'_{12}$ , between 0 and 1.5, depending upon the ratio of wing tank and duct cross-sectional areas, according to tabulated values assembled by Webster [B - 4].
3. Longitudinal structural stiffeners are assumed to protrude into the duct about every 5 feet or 1.5 meters. Each is assumed to contribute a loss coefficient of 0.95, so that the third loss source,  $C'_{13}$ , will be some multiple of 0.95.

### **Input Parameter Definitions, Free-Surface Stabilizer**

The use of an equation of the form of Equation 1 for free-surface stabilizers is justified by some old work of Dalzell [B - 5] [B - 6] in which it was shown that the moment generation capability of a series of free-surface stabilizers could reasonably be represented by a mechanical model which amounts to a moving weight roll stabilizer. Since the U-tube model was known to be essentially the same as the moving weight stabilizer model, it was reasonable to presume that the free-surface tank model could be squeezed into Equation 1 as well. In fact, there is little squeezing necessary. The same parameters, which were interpreted differently for the U-tube, are interpreted differently for the free surface tank.

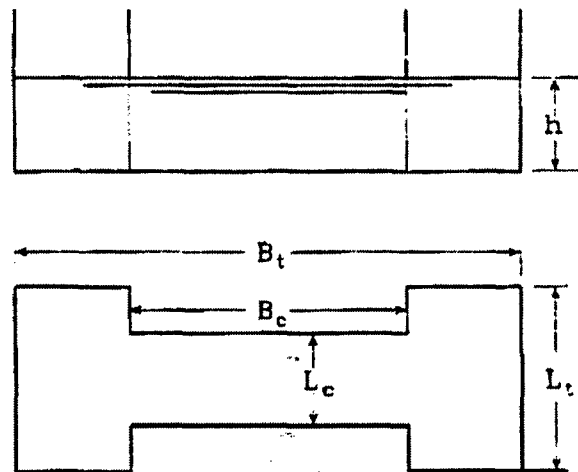
$I_w$       The transverse waterplane inertia is computed in exactly the same manner as for any other tank on the ship.

$l$  is  $(Z_0 + h / 2 - KG)$  where  $Z_0$  is the height of the tank bottom above the keel,  $h$  is the depth of water in the tank, and  $KG$  is the height of the ship center of gravity above the keel.

$\omega_t$  is not estimated in anything like the same way as in the U-tube case.

### Some Approximations for Free-Surface Tank Input

For the same reasons mentioned in connection with U-tube approximations, a pre-processor program called FSTANK was developed to ease the preparation of SMP95 input for free-surface tanks. As in the former case, the tank geometry is simplified for this purpose. Figure B - 2 indicates the simplified geometry, where the upper diagram is of a thwartship section through the tank and the lower is the planform. Everything except the depth of water,  $h$ , is in the plane of the free-surface tank. The thwartship overall length is denoted  $B_t$ , and the length of the crossover channel by  $B_c$ . Similarly, the (fore and aft width of the wing tank is denoted by  $L_t$  and the width of the crossover channel by  $L_c$ .



**Figure B - 2. Terminology, Simplified Free-surface Tank**

Free surface tanks come in three flavors: "H" type, "C" type, and "Rectangular". Figure B - 2 indicates the "H" type. In the C" type, one side or the other of the crossover channel is aligned



with the forward or aft end of the wing tanks, according to the location of the transverse ship bulkhead against which the tank is placed. For present purposes there is no difference between an "H" type tank and a "C" type. The Rectangular tank has no constriction of the crossover channel ( $L_c = L_t$ ). The flow is controlled to some extent by "picket fences" which are ordinarily placed near the quarter points of the tank.

A reasonable estimate of tank period is obtained by means of an "effective length" concept under which the tank frequency is estimated by the formula for the frequency of an unobstructed tank of a different than physical length [B - 5]. For the free surface tank the "effective length",  $B_E$ , is estimated by:

$$B_E = B_t + B_c \left[ \frac{L_t}{L_c} - 1 \right]$$

and then the tank frequency by:

$$\omega_t = \sqrt{\frac{g\pi}{B_E} \tanh\left(\pi \frac{h}{B_E}\right)}$$

Note that for the rectangular tank the formula yields  $B_E = B_t$ , and the tank frequency is what would be expected physically.

As far as damping is concerned, there is no physical way to proceed with estimates. The work on the mechanical model analogy [B - 5] suggested on the basis of analysis of an extensive series of experiments on one parent H type tank and one rectangular tank [B - 6] that the effective damping could be modeled as entirely quadratic. Thus, the default linear damping in the FSTANK preprocessor is  $\beta_L = 0$ .

The analysis of the same old experiments suggested an empirical non-dimensional form for the quadratic coefficient, which when translated into present notation and the conventions of Equation 1, becomes:

$$\beta_Q = C^* g^2 / \omega_t^2 R B_t$$

where  $R$  is the offset of the point at which  $\xi_7$  is defined and:

$C^* = 6.6$  for Rectangular tanks

$C^* = 5.0$  for H type tanks

It should be noted that the data base on which these results are based is slim. The reasons why the result is suggested for preliminary purposes are: 1) no other approach besides bench testing is known, and 2) the values of  $C^*$  are relatively close for two tanks of widely varying shape.

### Moving Weight Stabilizers

The moving weight stabilizer consists of a weight that is constrained to move athwartship on some sort of track, springs to provide a restoring force, and some form of damping device. There have been very few moving weight stabilizers built, and it is doubted that there is much demand. The capability to treat this type of stabilizer has been incorporated primarily because the incorporation consumed very little time.

The program is signaled to set up the moving weight stabilizer equations in a somewhat different way by the input stabilizer type specification. Once all the coefficients of the various motions are reduced to numerical form, there is no difference in the programming of the solutions for stabilized motions. As far as the program is concerned, at the outset the equation for the moving weight stabilizer is as follows:

$$m_7 \ddot{\xi}_2 + m_7 [g \xi_4 - l \ddot{\xi}_4] + m_7 \bar{X} \ddot{\xi}_6 + m_7 [\ddot{\xi}_7 + \omega_i^2 \xi_7] + 2m_7 \omega_i \beta_L \dot{\xi}_7 + \frac{m_7 \omega_i^2}{g} \beta_Q |\dot{\xi}_7| \dot{\xi}_7 = 0 \quad (3)$$

where the units of the equation are force, and:

$\xi_2$  is the sway motion,

$\xi_4$  is the roll motion,

$\xi_6$  is the yaw motion, and

$\xi_7$  is the athwartship linear motion of the weight. (In the tank case the use of a

vertical motion of tank fluid required a location parameter,  $R$ , which is absent here.)

$m_7$  is the mass of the moving weight. The actual input to the program is the volume,  $\bar{V}$ , of the equivalent mass of the water in which the ship floats. Thus the mass is computed as  $m_7 = \rho\gamma\bar{V}$ .

$\bar{X}$  is the longitudinal location of the stabilizer with respect to the ship longitudinal center of gravity.

$l$  is the vertical location, of the weight relative to the ship vertical center of gravity.

$\omega_i$  is the stabilizer natural frequency (rad/sec).

$\beta_L$  is a nondimensional linear damping coefficient.

$\beta_Q$  is a nondimensional quadratic damping coefficient.

Since this stabilizer is a mechanical device, estimates of the natural frequency, and perhaps the damping coefficients, are likely to be possible from first principles from the basic mechanics of the system.

## References

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- B - 2. Webster, W. C. and P. Dogan, "The Analysis of the Control of Activated Anti-roll Tanks," Hydronautics, Incorporated, Technical Report 490-2 (Dec 1966).
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## Appendix C Sample Input and Output Files

Sample input files and output file excerpts for SMPREGW and SMPIRGW for the DDG 79 Class Destroyer are presented in this Appendix. The DOS batch file RunSMP95.bat that is used to run the program is also listed.

### SMPREGW Input File

```
# SMP Regular Wave Input File
# Record Set 1 - Title
#DDG79R2V.inp - Full - NAVSEA Offsets Draft = 6.60m Trim = 0.30m GM = 1.26m
DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m
# Record Set 2 - Run Options
1 1 0 3 0 1 0 1 0
# Record Set 3 - Physical Units
METER 1025.8600 9.80620.00000119
# Record Set 4 - Hull Particulars
143.5600 18.1000 6.6000 9273.00 30.0000 10.0000 0.0000
# Record Set 5 - Load Particulars
1.2600 0.1500 7.5100 0.2500 0.3830 0.2500
# Record Set 6 - Hull Lines - Offsets - Weight Distribution
27 0 0 0 0
# Record Set 6b - Bow Profile offsets
4 0
0.00 -0.21 -0.25 -0.37
6.47 8.69 9.02 9.91
# Record Set 6c,d,e - Hull offsets
0.0000 8 0 4
0.0000 0.00 0.01 0.03 0.05 0.10 0.12 0.23 0.30
0.0000 6.16 6.31 6.45 6.60 7.02 7.19 7.87 8.22
0.2501 32 0 28
0.2501 0.00 0.39 0.77 1.21 1.52 1.94 2.19 2.48 2.67 2.78
2.78 2.69 2.50 2.23 1.91 1.52 1.22 0.82 0.58 0.40
0.26 0.19 0.19 0.19 0.22 0.28 0.37 0.40 0.47 0.49
0.64 0.74
0.2501 -2.78 -2.77 -2.74 -2.66 -2.56 -2.36 -2.19 -1.91 -1.60 -1.21
-0.85 -0.49 -0.14 0.13 0.35 0.54 0.68 0.91 1.11 1.39
1.80 2.57 3.34 4.11 4.88 5.65 6.41 6.60 7.02 7.19
7.93 8.30
0.4998 33 0 29
0.4998 0.00 0.48 0.78 1.14 1.55 1.97 2.27 2.63 2.84 3.06
3.10 3.08 2.97 2.74 2.48 2.11 1.82 1.46 1.15 0.84
0.59 0.48 0.41 0.39 0.41 0.46 0.55 0.67 0.74 0.84
0.88 1.01 1.22
0.4998 -2.87 -2.86 -2.84 -2.80 -2.71 -2.58 -2.42 -2.14 -1.89 -1.43
-1.16 -0.75 -0.40 -0.04 0.20 0.46 0.62 0.83 1.02 1.24
1.55 1.85 2.31 3.09 3.87 4.65 5.43 6.20 6.60 7.02
7.19 7.73 8.48
0.7499 31 0 27
0.7499 0.00 0.45 0.77 1.16 1.52 1.94 2.23 2.53 2.78 2.96
2.98 2.89 2.74 2.48 2.19 1.55 0.94 0.74 0.60 0.56
0.56 0.59 0.66 0.76 0.89 1.06 1.13 1.23 1.28 1.46
1.70
0.7499 -2.75 -2.74 -2.71 -2.66 -2.59 -2.44 -2.29 -2.06 -1.77 -1.35
-1.04 -0.61 -0.32 -0.03 0.21 0.63 1.09 1.38 1.77 2.19
2.54 3.30 4.07 4.83 5.58 6.33 6.60 7.02 7.19 7.81
8.54
1.0000 27 0 23
1.0000 0.00 0.42 0.74 1.16 1.46 1.88 2.13 2.42 2.60 2.67
```

	2.58	2.37	2.11	1.52	0.98	0.71	0.69	0.76	0.85	0.98
	1.14	1.31	1.52	1.65	1.71	1.98	2.24			
1.0000	-2.52	-2.50	-2.47	-2.40	-2.32	-2.15	-2.00	-1.72	-1.43	-1.09
	-0.71	-0.39	-0.15	0.30	0.81	1.49	2.23	2.97	3.70	4.43
	5.16	5.88	6.60	7.02	7.19	7.85	8.55			
1.5002	29	0	25							
1.5002	0.00	0.43	0.68	1.09	1.32	1.59	1.71	1.60	1.37	1.10
	0.91	0.78	0.73	0.71	0.75	0.83	0.92	1.11	1.28	1.47
	1.68	1.89	2.10	2.34	2.38	2.54	2.61	2.83	3.09	
1.5002	-1.94	-1.92	-1.89	-1.80	-1.68	-1.42	-1.14	-0.81	-0.57	-0.33
	-0.08	0.31	0.58	0.88	1.26	1.59	1.92	2.57	3.23	3.89
	4.54	5.19	5.84	6.48	6.60	7.02	7.19	7.75	8.38	
2.0000	24	0	20							
2.0000	0.00	0.33	0.53	0.44	0.27	0.25	0.34	0.50	0.66	0.96
	1.22	1.47	1.71	1.96	2.20	2.44	2.68	2.92	3.17	3.26
	3.44	3.52	3.66	3.91						
2.0000	-1.29	-1.24	-1.05	-0.80	-0.49	-0.13	0.11	0.38	0.65	1.19
	1.76	2.34	2.91	3.49	4.06	4.64	5.22	5.80	6.37	6.60
	7.02	7.19	7.52	8.09						
3.0000	21	0	17							
3.0000	0.00	0.31	0.53	0.96	1.36	1.73	2.08	2.42	2.75	3.07
	3.38	3.68	3.97	4.24	4.52	4.78	4.91	5.12	5.20	5.54
	5.80									
3.0000	0.11	0.11	0.26	0.64	1.05	1.49	1.95	2.41	2.88	3.36
	3.84	4.33	4.83	5.34	5.84	6.35	6.60	7.02	7.19	7.89
	8.41									
4.0000	23	0	19							
4.0000	0.00	0.31	0.56	1.06	1.54	2.00	2.44	2.87	3.28	3.67
	4.05	4.42	4.76	5.09	5.41	5.71	6.00	6.27	6.33	6.55
	6.63	6.79	7.04							
4.0000	0.09	0.09	0.18	0.45	0.77	1.12	1.49	1.87	2.28	2.70
	3.13	3.58	4.03	4.50	4.98	5.47	5.97	6.48	6.60	7.02
	7.19	7.51	8.03							
5.0000	24	0	20							
5.0000	0.00	0.31	0.57	1.12	1.65	2.16	2.66	3.15	3.61	4.06
	4.49	4.91	5.30	5.67	6.02	6.34	6.64	6.92	7.19	7.39
	7.59	7.67	7.91	8.14						
5.0000	0.08	0.08	0.13	0.30	0.53	0.79	1.08	1.39	1.73	2.09
	2.47	2.87	3.30	3.74	4.20	4.67	5.16	5.67	6.18	6.60
	7.02	7.19	7.75	8.28						
5.9873	25	0	21							
5.9873	0.00	0.31	0.59	1.17	1.73	2.29	2.84	3.37	3.88	4.38
	4.85	5.30	5.73	6.12	6.48	6.82	7.13	7.41	7.67	7.92
	8.09	8.26	8.33	8.56	8.76					
5.9873	0.06	0.06	0.09	0.18	0.33	0.52	0.74	0.99	1.27	1.58
	1.93	2.31	2.72	3.15	3.61	4.10	4.60	5.11	5.64	6.17
	6.60	7.02	7.19	7.81	8.37					
7.0000	26	0	22							
7.0000	0.00	0.31	0.60	1.21	1.81	2.40	2.99	3.56	4.12	4.66
	5.17	5.64	6.08	6.49	6.86	7.20	7.51	7.80	8.06	8.29
	8.50	8.57	8.69	8.75	8.86	9.03				
7.0000	0.05	0.05	0.06	0.11	0.19	0.30	0.45	0.64	0.87	1.15
	1.47	1.85	2.26	2.71	3.19	3.68	4.20	4.73	5.28	5.84
	6.41	6.60	7.02	7.19	7.56	8.14				
7.9830	26	0	22							
7.9830	0.00	0.31	0.62	1.24	1.85	2.47	3.08	3.68	4.27	4.84
	5.38	5.89	6.35	6.77	7.15	7.50	7.81	8.08	8.33	8.54
	8.72	8.84	8.94	8.99	9.17	9.31				
7.9830	0.03	0.03	0.04	0.06	0.10	0.17	0.26	0.40	0.58	0.82
	1.12	1.48	1.90	2.35	2.84	3.35	3.88	4.44	5.00	5.59

	6.18	6.60	7.02	7.19	7.98	8.58					
8.9809	26	0	22								
8.9809	0.00	0.31	0.63	1.25	1.88	2.50	3.12	3.74	4.35	4.94	
	5.51	6.04	6.54	6.99	7.39	7.74	8.05	8.30	8.52	8.70	
	8.85	8.99	9.08	9.11	9.23	9.35					
8.9809	0.02	0.02	0.02	0.04	0.08	0.13	0.20	0.30	0.45	0.65	
	0.91	1.23	1.61	2.05	2.53	3.04	3.59	4.16	4.75	5.35	
	5.95	6.60	7.02	7.19	7.79	8.41					
10.0000	27	0	23								
10.0000	0.00	0.31	0.63	1.26	1.88	2.51	3.14	3.76	4.37	4.98	
	5.56	6.12	6.64	7.11	7.53	7.89	8.19	8.43	8.62	8.77	
	8.90	9.02	9.05	9.12	9.15	9.24	9.35				
10.0000	0.00	0.00	0.00	0.03	0.06	0.11	0.19	0.28	0.41	0.58	
	0.81	1.10	1.46	1.87	2.34	2.86	3.41	3.99	4.59	5.20	
	5.82	6.43	6.60	7.02	7.19	7.67	8.29				
11.0000	27	0	23								
11.0000	0.00	0.31	0.63	1.26	1.88	2.51	3.13	3.75	4.36	4.97	
	5.55	6.11	6.63	7.11	7.53	7.90	8.20	8.44	8.63	8.78	
	8.90	9.02	9.05	9.13	9.15	9.24	9.35				
11.0000	-0.01	-0.01	0.00	0.02	0.06	0.12	0.20	0.30	0.44	0.61	
	0.84	1.13	1.48	1.89	2.35	2.86	3.41	3.99	4.59	5.20	
	5.81	6.43	6.60	7.02	7.19	7.67	8.29				
12.0000	26	0	22								
12.0000	0.00	0.31	0.62	1.24	1.86	2.47	3.08	3.69	4.29	4.87	
	5.44	5.99	6.51	7.00	7.44	7.84	8.17	8.43	8.62	8.77	
	8.89	9.03	9.11	9.14	9.23	9.34					
12.0000	-0.03	-0.03	-0.02	0.03	0.11	0.20	0.31	0.44	0.61	0.81	
	1.06	1.35	1.69	2.08	2.51	2.98	3.51	4.07	4.66	5.27	
	5.87	6.60	7.02	7.19	7.71	8.32					
13.0000	26	0	22								
13.0000	0.00	0.31	0.61	1.21	1.80	2.40	2.98	3.56	4.13	4.69	
	5.24	5.77	6.29	6.78	7.24	7.67	8.03	8.32	8.54	8.71	
	8.84	8.96	9.04	9.08	9.19	9.30					
13.0000	-0.04	-0.04	0.00	0.09	0.21	0.35	0.51	0.70	0.91	1.16	
	1.43	1.73	2.05	2.40	2.80	3.23	3.72	4.26	4.83	5.41	
	6.00	6.60	7.02	7.19	7.80	8.40					
14.0000	26	0	22								
14.0000	0.00	0.31	0.58	1.15	1.71	2.26	2.81	3.35	3.89	4.42	
	4.94	5.46	5.97	6.47	6.94	7.39	7.78	8.10	8.37	8.57	
	8.73	8.83	8.91	8.95	9.09	9.20					
14.0000	-0.06	-0.06	0.01	0.20	0.40	0.62	0.84	1.08	1.33	1.60	
	1.88	2.17	2.48	2.80	3.16	3.56	4.00	4.50	5.03	5.59	
	6.16	6.60	7.02	7.19	7.90	8.49					
14.3100	26	0	22								
14.3100	0.00	0.31	0.57	1.11	1.65	2.19	2.73	3.26	3.79	4.32	
	4.84	5.35	5.86	6.35	6.83	7.28	7.68	8.02	8.30	8.51	
	8.68	8.77	8.86	8.88	9.04	9.16					
14.3100	-0.06	-0.06	0.04	0.28	0.52	0.75	0.99	1.24	1.50	1.77	
	2.04	2.33	2.63	2.95	3.29	3.67	4.10	4.58	5.10	5.65	
	6.22	6.60	7.02	7.19	7.95	8.53					
14.3949	30	0	26								
14.3949	0.00	0.31	0.47	0.92	1.37	1.82	2.27	2.72	3.17	3.62	
	4.07	4.51	4.94	5.37	5.80	6.22	6.63	7.03	7.39	7.72	
	8.01	8.24	8.44	8.60	8.72	8.76	8.85	8.88	9.02	9.12	
14.3949	-0.06	-0.06	0.04	0.24	0.44	0.65	0.86	1.06	1.27	1.48	
	1.70	1.93	2.17	2.41	2.66	2.92	3.20	3.50	3.84	4.21	
	4.61	5.05	5.50	5.97	6.45	6.60	7.02	7.19	7.91	8.40	
15.0000	29	0	25								
15.0000	0.00	0.31	0.44	0.80	1.20	1.62	2.05	2.48	2.92	3.36	
	3.80	4.24	4.67	5.10	5.53	5.95	6.36	6.77	7.15	7.50	



	7.81	8.07	8.28	8.46	8.60	8.70	8.74	8.90	9.00	
15.0000	-0.07	-0.07	0.05	0.38	0.67	0.92	1.16	1.38	1.60	1.82
	2.03	2.25	2.47	2.70	2.95	3.20	3.46	3.73	4.04	4.38
	4.76	5.17	5.61	6.07	6.60	7.02	7.19	7.97	8.45	
16.0000	30	0	27							
16.0000	0.00	0.17	0.25	0.41	0.65	0.99	1.39	1.82	2.26	2.71
	3.15	3.60	3.83	3.84	4.04	4.49	4.92	5.36	5.79	6.22
	6.63	7.01	7.36	7.66	7.92	8.12	8.26	8.38	8.43	8.62
16.0000	-0.09	-0.08	0.21	0.67	1.10	1.44	1.72	1.95	2.16	2.36
	2.56	2.75	2.86	2.86	2.95	3.16	3.37	3.59	3.81	4.05
	4.31	4.61	4.95	5.33	5.75	6.19	6.60	7.02	7.19	8.07
17.0000	28	0	24							
17.0000	0.00	0.04	0.35	0.71	1.10	1.50	1.90	2.31	2.72	3.13
	3.54	3.95	4.35	4.76	5.16	5.57	5.96	6.34	6.71	7.03
	7.30	7.51	7.69	7.78	7.91	7.96	8.08	8.19		
17.0000	2.01	2.01	2.26	2.49	2.69	2.86	3.01	3.16	3.31	3.46
	3.60	3.75	3.90	4.05	4.21	4.37	4.55	4.76	5.00	5.29
	5.63	6.00	6.40	6.60	7.02	7.19	7.64	8.06		
18.0000	25	0	21							
18.0000	0.00	0.39	0.79	1.18	1.58	1.97	2.36	2.75	3.14	3.53
	3.92	4.31	4.70	5.08	5.46	5.82	6.17	6.48	6.75	6.97
	7.13	7.28	7.34	7.51	7.62					
18.0000	3.70	3.77	3.85	3.92	4.00	4.08	4.16	4.24	4.33	4.42
	4.52	4.62	4.73	4.85	4.99	5.16	5.36	5.60	5.90	6.24
	6.60	7.02	7.19	7.75	8.13					
19.0000	24	0	20							
19.0000	0.00	0.37	0.74	1.11	1.48	1.85	2.21	2.58	2.95	3.32
	3.68	4.05	4.41	4.77	5.11	5.44	5.73	5.99	6.21	6.28
	6.45	6.52	6.76	6.87						
19.0000	4.84	4.86	4.88	4.91	4.94	4.97	5.01	5.05	5.10	5.14
	5.19	5.25	5.32	5.42	5.56	5.74	5.96	6.22	6.52	6.60
	7.02	7.19	7.90	8.25						
20.0000	21	0	17							
20.0000	0.00	0.34	0.67	1.01	1.34	1.68	2.01	2.35	2.69	3.02
	3.36	3.69	4.01	4.33	4.62	4.86	5.04	5.27	5.36	5.68
	5.81									
20.0000	5.57	5.58	5.60	5.61	5.62	5.63	5.64	5.65	5.67	5.69
	5.73	5.78	5.86	5.98	6.15	6.38	6.60	7.02	7.19	7.84
	8.15									
# Record Set	6g - Stern Profile offsets									
4	0									
	19.98	20.00	20.08	20.19						
	5.57	6.17	8.22	11.05						
# Record Set	7 - Sonar Dome Particulars									
1										
0.0000	2.0000	0.1486	-2.8814							
# Record Set	8 - Bilgekeel Particulars									
1										
7	7.4700	14.1600	0.9140							
7.9830	6.9400	2.6138	45.0000							
8.9809	7.1000	2.2289	45.0000							
10.0000	7.2100	2.0236	45.0000							
11.0000	7.1900	1.9786	45.0000							
12.0000	7.1300	2.1736	45.0000							
13.0000	7.0400	2.5686	45.0000							
14.0000	6.9400	3.1036	45.0000							
# Record Set	9 - Fin Particulars, Input is for Rudders for Rudder Roll Stabilization									
1	1	0	1	20.0000	5.0000					
# Record Set	9b - Speed Dependent Reduction Factors									
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		

```

# Record Set 9c - Speed Dependent Gain Factors
  0.0000  2.5000  3.4000  2.0000
#   0.0000  2.4000  2.5000  2.8000  3.4000  3.9000  2.0000
# Record Set 9d - Fin Controller Coefficients
  0.0000  1.0000  0.0000
# Record Set 9e - Fin Servo Coefficients
  0.9848  0.2865  0.0000
# Record Set 9f - Fin Controller Compensation Coefficients
  1.0000  0.0000  0.0000
# Record Set 9h - Fin Geometry
  19.2600  19.9000  3.1000  4.4500  4.4400
  19.4200  19.7600  3.1000  0.3600  0.3500
# Record Set 10 - Skeg Particulars
  1
  15.5000  16.5000  18.0000  0.0000  -0.0689  -0.0839  3.7036
# Record Set 11 - Propeller Shaft Particulars
  1
  1      0.7500  16.3480  4.1150  1.8110  18.2590  4.1150  1.1250
# Record Set 12 - Propeller Shaft Bracket Particulars
  1
  18.4600  18.6000  5.5400  5.3967  5.4967
  18.4600  18.6000  4.1100  1.2567  1.1767
  18.4600  18.6000  0.9300  4.2467  4.3467
# Record Set 13 - Propeller Particulars
  1
  18.7250  4.1150  0.9910  5.1820  0.9350  0.9650  0.9300  1.0000
  0.7491  -0.2941  -0.0998  0.1223  -0.0101  -0.0471
  1  13
  0.0000  0.0000
  0.1371  0.0836
  0.1645  0.0856
  0.1919  0.0876
  0.2194  0.0891
  0.2468  0.0907
  0.2742  0.0938
  0.3016  0.1001
  0.3291  0.1020
  0.3565  0.1062
  0.3839  0.1225
  0.4113  0.1458
  0.4387  0.1650
# Record Set 14 - Rudder Particulars, See Record Set 9 for Rudder Roll Stabilization
  0
# Record Set 15 - Passive Stabilizer Particulars
  0
# Record Set 16 - Sinkage and Trim, from DDG 51 Model 5415 test
  1
  7
  0.0000  0.0000  0.0000
  0.0690  0.0400  -0.0400
  0.1370  0.0800  -0.0800
  0.2060  0.1500  -0.1800
  0.2740  0.2600  -0.3000
  0.3730  0.4100  -0.3600
  0.4120  0.6300  0.6900
# Record Set 17 - Station, Wave Profile, from DDG 51 Model 5415 test
#   for helicopter deck wetness at stern
  1
  3  4
  0.0000  17.0000  0.0000

```

0.0000	18.0000	0.0000
0.0000	19.0000	0.0000
0.0000	20.2000	0.0000
0.2740	17.0000	-0.0630
0.2740	18.0000	0.2520
0.2740	19.0000	0.4100
0.2740	20.2000	0.4100
0.4120	17.0000	0.1580
0.4120	18.0000	0.5670
0.4120	19.0000	1.0400
0.4120	20.2000	1.1980

# Record Set 18 - Roll Damping Model Selection  
# for Development only  
# Record Set 19 - Stop  
STOP

## SMPREGW Output File Excerpts

SMP95 - REGULAR WAVE MODULE

NSWC/CD - DTMB

SEAKEEPING DEPARTMENT - CODE 5500

DATE = 21-NOV-05

TIME = 16:01:52

SMPREGW audit trail = 21-NOV-05 16:01:52

### I N P U T   C A R D S

#### C O L U M N

	1	2	3	4	5	6	7	8
LINE	1234567890123456789012345678901234567890123456789012345678901234567890							

1	#	SMP	Regular	Wave	Input	File		
2	#	Record	Set	1	-	Title		
3	#	DDG79R2V.inp	-	Full	-	NAVSEA	Offsets	Draft = 6.60m Trim = 0.30m GM = 1.26m
4		DDG79R2V	NSEA	Offsets	Dr	6.60m	GM	1.26m Tr 0.30m
5	#	Record	Set	2	-	Run	Options	
6		1	1	0	3	0	1	0
7	#	Record	Set	3	-	Physical	Units	
8	METER		1025.8600		9.80620.00000119			
9	#	Record	Set	4	-	Hull	Particulars	
10		143.5600	18.1000	6.6000	9273.00	-30.0000	10.0000	0.0000
11		4						
12		0.0000	10.0000	20.0000	30.0000			
13	#	Record	Set	5	-	Load	Particulars	
14		1.2600	0.1500	7.5100	0.2500	0.3830	0.2500	
15	#	Record	Set	6	-	Hull	Lines - Offsets - Weight	Distribution
16		27	0	0	0	0		
17	#	Record	Set	6b	-	Bow	Profile	offsets
18		4	0					
19			0.00	-0.21	-0.25	-0.37		
20			6.47	8.69	9.02	9.91		

# LIMITS ON ARRAY INPUTS - REGULAR WAVE MODULE

Input	Variable	Limit	Record
	Name	Name	Set
Speeds	NVK	MXNVK	8 4
(Note: For some options NVK is calculated from data in the indicated record)			
Input stations	NSTATN	MXNSTATN	70 6
(Note: if VGOPTN = 1 the maximum number of input stations allowed is reduced by 2)			
Load stations	NLOADS	MXNLOADS	10 6
Offsets per station	NOFSET	MXNOFSET	70 6
(Note: if VGOPTN = 1 the maximum number of offsets per station allowed is reduced by 1)			
Sonar domes	NSDSET	MXNSDSET	1 7
Bilge keel sets	NBKSET	MXNBKSET	2 8
Bilge keel stations	NBKSTN	MXNBKSTN	15 8
Fin sets	NFNSSET	MXNFNSSET	2 9
Skeg sets	NSKSET	MXNSKSET	2 10
Propeller shaft sets	NPSSET	MXNPSSET	6 11
Shaft bracket sets	NSBSET	MXNSBSET	2 12
Propeller sets	NPRSET	MXNPRSET	2 13
Maximum number of coeffs to define resistance	NRESC	MXNRESC	30 13
Rudder sets	NRDSET	MXNRDSET	2 14
Passive stabilizers	NPSTAB	MXNPSTAB	3 15
Sinkage and trim input values	NSTRI	MXNSTRI	10 16
Wave profile - froude number values read in	NWPRIFN	MXNWPRIFN	12 17
Wave profile - input station values read in	NWPRIST	MXNWPRIST	15 17
Wave profile - station values	NWPST	MXNWPST	15 17

(Note: An array limit can be changed by changing the corresponding parameter <limit name> in the file PARAM.DEF and recompiling.)

# INPUT DESCRIPTION

## RECORD SET 1 - TITLE

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

## RECORD SET 2 - PROGRAM OPTIONS

OPTION	VLACPR	RAOPR	RLDMPR	LRAOPR	ADPR	ORGOPTN	VGOPTN
1	1	0	3	0	1	0	1

## RECORD SET 3 - PHYSICAL UNITS

UNITS	RHO	GRAV	GNU
METER	1025.8600	9.8062	0.00000119

## RECORD SET 4 - HULL PARTICULARS

LPP	BEAM	DRAFT	DSPLMT	VKDES	VKINC	AMODL
143.5600	18.1000	6.6000	9273.00	-30.0000	10.0000	0.0000

Input value of NVK = 4

Input values of NVK

0.0000
10.0000
20.0000
30.0000

	GNOM	DELM	KG	KPITCH	KROLL	KYAW
	1.26	0.15	7.51	0.25	0.38	0.25

NO. OF STATIONS = 27	NLOADS = 0	NBB = 0	LKNPF = 0
----------------------	------------	---------	-----------

NBP	KNFBP
4	0

$$\begin{array}{ccccccc} \text{STA} & = & 0.00 & -0.21 & -0.25 & -0.37 \\ \text{Z} & = & 6.47 & 8.69 & 9.02 & 9.91 \end{array}$$

STATION    NOFFSET   KNP   NPTOSOFFSETS-   Y=HALF BREADTH,   Z=WATERLINE (FROM KEEL)

[illegible]

# STERN PROFILE

NSP	KNFSP			
4	0			
STA =	0.00	0.00	0.00	0.00
Z =	5.57	6.17	8.22	11.05

RECORD SET 7 - SONAR DOME PARTICULARS

NSDSET				
1				
SDFST	SDAST	SDRWL	SDTWL	
0.000	2.000	0.149	-2.881	

## RECORD SET 8 - BILGE KEEL PARTICULARS

NEKSET				
1				
BKSET	NEKSTN	BKFS	BKAS	BKWD
1	7	7.4700	14.1600	0.9140
BKSTN	BKHB	BKWL	BKAN	
7.9830	6.9400	2.6138	45.0000	
8.9809	7.1000	2.2289	45.0000	
10.0000	7.2100	2.0236	45.0000	
11.0000	7.1900	1.9786	45.0000	
12.0000	7.1300	2.1736	45.0000	
13.0000	7.0400	2.5686	45.0000	
14.0000	6.9400	3.1036	45.0000	

TOTAL BILGE KEEL LENGTH = 48.0208      AVERAGE SPAN = 0.9140



RECORD SET 9 - FIN PARTICULARS

NFNSSET	IACFN	IFCLCS	IAGC	FALIM	FVLIM
1	1	0	1	20.000	5.000

SHIP SPEED (KNOTS) = 0.000 10.000 20.000 30.000

FIN ANGLE LIMIT REDUCTION FACTORS = 1.000 1.000 1.000 1.000 1.000

FIN FIXED GAIN FACTORS = 0.000 2.500 3.400 2.000

CONTROLLER COEFF. = 0.000 1.000 0.000

SERVO COEFFICIENTS = 0.985 0.287 0.000

COMPENSATION COEFF.= 1.000 0.000 0.000

FNSSET	LOCATION	FWDSTN	AFTSTN	HLFBM	FWDWL	AFTWL
1	ROOT	19.2600	19.9000	3.1000	4.4500	4.4400
1	TIP	19.4200	19.7600	3.1000	0.3600	0.3500

RECORD SET 10 - SKEG PARTICULARS

NSKSET

1

SKSET	SKFLS	SKALS	SKAUS	SKHB	SKFLWL	SKALWL	SKAUWL
1	15.5000	16.5000	18.0000	0.0000	-0.0689	-0.0839	3.7036

RECORD SET 11 - PROPELLER SHAFT PARTICULARS

NPSSET

1

IPSPR	PSDIA	PSFST	PSFHB	PSFWL	PSAST	PSAHB	PSAWL
1	0.7500	16.3480	4.1150	1.8110	18.2590	4.1150	1.1250

# RECORD SET 12 - PROPELLER SHAFT BRACKETS

NSBSET

1

SBSET	LOCATION	FWDSTN	AFTSTN	HLFEM	FWDWL	AFTWL
1	RTOB	18.4600	18.6000	5.5400	5.3967	5.4967
1	TIP	18.4600	18.6000	4.1100	1.2567	1.1767
1	RTIB	18.4600	18.6000	0.9300	4.2467	4.3467

# RECORD SET 13 - PROPELLER PARTICULARS

NPRSET

1

## PROPELLER CHARACTERISTICS

I	PRST	PRHB	PRWL	IM	DIAM	TDC	WAKET	WAKEQ	PSRATIO
1	18.725	4.11	0.99	2.	5.182	0.9350	0.9650	0.9300	1.000

I ----- CKT ----- CKQ -----

1	7.49100E-01	-2.94100E-01	-9.98000E-02	1.22300E-01	-1.01000E-02	-4.71000E-02
---	-------------	--------------	--------------	-------------	--------------	--------------

## RESISTANCE CURVE

Number of terms = 13

I	FN	CTOTAL
1	0.00000E+00	0.00000E+00
2	1.37100E-01	8.36000E-02
3	1.64500E-01	8.56000E-02
4	1.91900E-01	8.76000E-02
5	2.19400E-01	8.91000E-02

6	2.46800E-01	9.07000E-02
7	2.74200E-01	9.38000E-02
8	3.01600E-01	1.00100E-01
9	3.29100E-01	1.02000E-01
10	3.56500E-01	1.06200E-01
11	3.83900E-01	1.22500E-01
12	4.11300E-01	1.45800E-01
13	4.38700E-01	1.65000E-01

RECORD SET 14 - RUDDER PARTICULARS

NRDSET

0

RECORD SET 15 - NO PASSIVE STABILIZERS

RECORD SET 16 - SINKAGE AND TRIM

STOPTN

1

NSTRI

7

FROUDE NUMBER	SINKAGE	TRIM
0.00000	0.00000	0.00000
0.06900	0.04000	-0.04000
0.13700	0.08000	-0.08000
0.20600	0.15000	-0.18000
0.27400	0.26000	-0.30000

0.37300      0.41000      -0.36000  
0.41200      0.63000      0.69000

RECORD SET 17 - WAVE PROFILE

WPOPTN

1

NWPRIN      NWPRIST

3

NWPRIN      NWPRIST

4

FROUDE NUMBER	STATION	WAVE ELEVATION
0.00000	17.00000	0.00000
0.00000	18.00000	0.00000
0.00000	19.00000	0.00000
0.00000	20.20000	0.00000
0.27400	17.00000	-0.06300
0.27400	18.00000	0.25200
0.27400	19.00000	0.41000
0.27400	20.20000	0.41000
0.41200	17.00000	0.15800
0.41200	18.00000	0.56700
0.41200	19.00000	1.04000
0.41200	20.20000	1.19800

RECORD SET 20 - STOP

STOP

NATURAL ROLL PERIOD TPhi Seconds

IROLLG = 459089408.0

TPhi air w/o appendages = 11.35

A44G = 110707544.0

TPhi wet w/o appendages = 12.65

A44G = 107696528.0

TPhi wet w/o appendages = 12.61

For NATPER call 1 to RDEVAL

A44G = 107772424.0

A44AP = 75939.9

TPhi wet with appendages = 12.62

D44G = 5331685.5

ET = 0.0000

## TABLE OF SHIP PARTICULARS

## SHIP CHARACTERISTICS -

SHIP LENGTH (LPP)	143.56 METERS	LENGTH/BEAM	7.931
BEAM AT MIDSHIPS	18.10 METERS	BEAM/DRAFT	2.742
DRAFT AT MIDSHIPS	6.60 METERS	DRAFT/BEAM	0.365
DISPLACEMENT (S.W.)	9553.1 M. TONS	VOLUME/(.1LPP)**3	3.147
DESIGN SHIP SPEED	30.00 KNOTS	FROUDE NUMBER	0.412

## VERTICAL LOCATIONS -

C. OF GRAVITY (VCG)*	1.06 METERS	VCG/BEAM	0.058
C. OF GRAVITY (KG)**	7.66 METERS	KG/BEAM	0.423
METACENTRIC HT. (GM)	1.50 METERS	GM/BEAM	0.083
METACENTER (KM)**	9.16 METERS	KM/BEAM	0.506
C. OF BUOYANCY (KB)**	4.00 METERS	KB/BEAM	0.221

## LONGITUDINAL LOCATIONS\*\*\* -

C. OF GRAVITY (LCG)	74.76 METERS	LCG/LENGTH	0.521
C. OF BUOYANCY (LCB)	74.76 METERS	LCB/LENGTH	0.521
C. OF FLOTATION (LCF)	88.84 METERS	LCF/LENGTH	0.619

## MOTION CHARACTERISTICS -

ROLL GYRADIUS	6.93 METERS	RG/BEAM	0.383
PITCH GYRADIUS	35.89 METERS	PG/LPP	0.250
YAW GYRADIUS	35.89 METERS	YG/LPP	0.250
ESTIMATED ROLL PERIOD	12.62 SECONDS	ROLL FREQ (RADIAN)	0.498

## COMPUTED AREAS -

WATERPLANE	2440.2 SQ. METERS AWP/(LPP*BEAM)	0.939
WETTED SURFACE, HULL	3450.3 SQ. METERS WS/(2LD+2BD+LB)	0.729

## HULL COEFFICIENTS -

BLOCK (CB)	0.543
SECTION (CX)	0.832
PRISMATIC (CP)	0.653

\* WATERLINE REFERENCE

\*\* KEEL REFERENCE

\*\*\*F.P. REFERENCE

TABLE OF SHIP APPENDAGE PARTICULARS

BILGE KEEL CHARACTERISTICS -

BILGE KEEL LENGTH (SET NO. 1)	48.02 METERS
BILGE KEEL WIDTH (SET NO. 1)	0.91 METERS
TOTAL WETTED SURFACE AREA (B.K. SET NO. 1)	175 SQ. METERS

SKEG CHARACTERISTICS -

SKEG LENGTH ALONG KEEL (SET NO. 1)	7.18 METERS
SKEG HEIGHT (SET NO. 1)	3.79 METERS
TOTAL WETTED SURFACE AREA (SKEG SET NO. 1)	27 SQ. METERS

PROPELLER SHAFT BRACKETS CHARACTERISTICS -

OUTSIDE BRACKET ROOT CHORD LENGTH (SET NO. 1)	1.00 METERS
OUTSIDE BRACKET MEAN SPAN (SET NO. 1)	4.47 METERS
BRACKET TIP CHORD LENGTH (SET NO. 1)	1.00 METERS
INSIDE BRACKET ROOT CHORD LENGTH (SET NO. 1)	1.00 METERS
INSIDE BRACKET MEAN SPAN (SET NO. 1)	4.43 METERS
TOTAL WETTED SURFACE AREA (BRACKET SET NO. 1)	34 SQ. METERS

FIN CHARACTERISTICS -

FIN ROOT CHORD LENGTH (SET NO. 1)	4.59 METERS
FIN TIP CHORD LENGTH (SET NO. 1)	2.44 METERS
FIN MEAN SPAN (SET NO. 1)	4.09 METERS
TOTAL WETTED SURFACE AREA (FIN SET NO. 1)	57 SQ. METERS

NOTE: IF A "SET" REPRESENTS A PAIR OF APPENDAGES (E.G., BILGE KEELS),  
THEN THE WETTED SURFACE IS COMPUTED FOR THE TOTAL AREA OF BOTH APPENDAGES.

# HULL SECTION CHARACTERISTICS

STATION	BEAM	DRAFT	A_S/BT	B@WL	SAREA	X (+ AFT FROM MIDSHIPS)	
-0.01	0.00	0.00	0.00	0.00	0.00	-71.86	1
0.00	0.10	0.44	0.43	0.10	0.02	-71.78	4
0.25	5.58	9.38	0.37	0.80	19.48	-69.98	28
0.50	6.20	9.47	0.43	1.48	25.42	-68.19	29
0.75	5.96	9.35	0.47	2.26	25.96	-66.40	27
1.00	5.33	9.12	0.51	3.04	24.71	-64.60	23
1.50	4.76	8.54	0.57	4.76	23.32	-61.01	25
2.00	6.52	7.89	0.49	6.52	25.37	-57.42	20
3.00	9.82	6.49	0.60	9.82	38.18	-50.25	17
4.00	12.66	6.51	0.63	12.66	51.73	-43.07	19
5.00	14.78	6.52	0.67	14.78	64.27	-35.89	20
5.99	16.18	6.54	0.71	16.18	75.26	-28.80	21
7.00	17.14	6.55	0.75	17.14	84.62	-21.53	22
7.98	17.68	6.57	0.79	17.68	91.79	-14.48	22
8.98	17.98	6.58	0.82	17.98	96.77	-7.32	22
10.00	18.10	6.60	0.83	18.10	99.40	0.00	23
11.00	18.10	6.61	0.83	18.10	99.22	7.18	23
12.00	18.06	6.63	0.81	18.06	96.43	14.36	22
13.00	17.92	6.64	0.76	17.92	90.75	21.53	22
14.00	17.66	6.66	0.70	17.66	82.68	28.71	22
14.31	17.54	6.66	0.68	17.54	79.45	30.94	22
14.39	17.52	6.66	0.67	17.52	78.44	31.55	26
15.00	17.20	6.67	0.62	17.20	71.56	35.89	25
16.00	16.52	6.69	0.53	16.52	58.37	43.07	27
17.00	15.56	4.59	0.60	15.56	43.21	50.25	24
18.00	14.26	2.90	0.70	14.26	28.95	57.42	21
19.00	12.56	1.76	0.77	12.56	16.93	64.60	20
20.00	10.08	1.03	0.82	10.08	8.51	71.78	17
20.02	0.00	0.00	0.00	0.00	0.00	71.89	1



## SHIP PARTICULARS

LPP = 143.56 GM = 1.50  
 BEAM = 18.10 KROLL = 0.38B  
 DRAFT = 6.60 WPHI = 0.498  
 DISPLM = 9553. TPFI = 12.62

## HULL AND APPENDAGE PARTICULARS

	Q	GAMMA	MCHORD	MSPAN	AREA	XCP	YCP	ZCP	YHAT	EAR	LCS
HULL	1.	-90.0	143.56	6.60	947.50	78.44	0.00	0.00	0.00	0.092	0.144
SKEG	1.	-90.0	3.59	3.74	13.41	-41.28	0.00	-7.40	7.40	2.082	3.271
BRACKET	2.	71.3	1.00	4.47	4.49	-58.00	4.82	-4.71	-2.92	8.887	6.283
BRACKET	2.	-40.9	1.00	4.21	4.23	-58.00	2.52	-5.45	5.47	8.376	6.283
BILGEKEEL	2.	-45.0	48.02	0.91	43.89	-2.87	7.67	-4.93	8.91	0.038	0.060
FIN	2.	-90.0	3.52	4.09	14.39	-64.94	3.10	-5.68	5.68	2.326	2.699

## SHIP ROLL DECAY COEFFICIENT, N

SHIP SPEED (KNOTS)	MEAN ROLL ANGLE (SA) (DEGREES)	0.5	1.0	2.5	5.0	10.0	15.0	25.0	40.0
0.	0.021370	0.025922	0.035161	0.046118	0.063974	0.079257	0.107657	0.153754	
10.	0.070085	0.074147	0.081975	0.090636	0.103356	0.113261	0.129639	0.151644	
20.	0.122939	0.126814	0.134193	0.142213	0.153696	0.162343	0.175991	0.192708	
30.	0.195353	0.199484	0.207482	0.216300	0.229044	0.238666	0.253775	0.271806	

Total non-wavemaking roll damping B44 (dimensional)

SHIP SPEED (KNOTS)	MEAN ROLL ANGLE (SA) (DEGREES)	0.50	1.00	2.50	5.00	10.00	15.00	25.00	40.00
0.	9.52713E+06	1.20976E+07	1.73150E+07	2.35021E+07	3.35850E+07	4.22150E+07	5.82520E+07	8.42820E+07	
10.	3.70356E+07	3.93294E+07	4.37498E+07	4.86402E+07	5.58232E+07	6.14162E+07	7.06645E+07	8.30907E+07	
20.	6.68813E+07	6.90695E+07	7.32365E+07	7.77650E+07	8.42489E+07	8.91321E+07	9.68385E+07	1.06278E+08	
30.	1.07772E+08	1.10104E+08	1.14621E+08	1.19601E+08	1.26797E+08	1.32230E+08	1.40762E+08	1.50943E+08	

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

ROLL DECAY COEFFICIENTS GROUPED BY  
HULL AND APPENDAGES

BARE HULL PLUS SKEG  
(WAVEMAKING, SKIN FRICTION, EDDYMAKING, AND LIFT)

SHIP SPEED (KNOTS)	MEAN ROLL ANGLE (SA) (DEGREES)					
	0.5	1.0	2.5	5.0	10.0	15.0 25.0 40.0
0.	0.005240	0.005787	0.007430	0.010168	0.016774	0.023618 0.038857 0.069705
10.	0.015415	0.015545	0.015934	0.016583	0.018407	0.020194 0.024013 0.031627
20.	0.025516	0.025556	0.025677	0.025879	0.026732	0.027468 0.028889 0.031621
30.	0.038568	0.038587	0.038642	0.038735	0.039412	0.039930 0.040812 0.042374

PROPELLER SHAFT BRACKETS  
(EDDYMAKING PLUS LIFT)

SHIP SPEED (KNOTS)	MEAN ROLL ANGLE (SA) (DEGREES)					
	0.5	1.0	2.5	5.0	10.0	15.0 25.0 40.0
0.	0.000014	0.000028	0.000069	0.000138	0.000277	0.000415 0.000692 0.001107
10.	0.008465	0.008468	0.008478	0.008494	0.008526	0.008558 0.008621 0.008717
20.	0.016789	0.016789	0.016792	0.016797	0.016806	0.016815 0.016833 0.016860
30.	0.029064	0.029064	0.029066	0.029069	0.029074	0.029080 0.029091 0.029107

BILGEKEEL  
(EDDYMAKING PLUS LIFT)

SHIP SPEED (KNOTS)	MEAN ROLL ANGLE (SA) (DEGREES)					
	0.5	1.0	2.5	5.0	10.0	15.0 25.0 40.0
0.	0.010763	0.014873	0.022812	0.031531	0.043586	0.052676 0.066878 0.083308
10.	0.012665	0.016775	0.024714	0.033433	0.045488	0.054578 0.068780 0.085210
20.	0.014541	0.018652	0.026590	0.035309	0.047364	0.056455 0.070657 0.087087
30.	0.016603	0.020713	0.028652	0.037371	0.049426	0.058516 0.072718 0.089148

SHIP SPEED (KNOTS)		FIN (EDDYMAKING PLUS LIFT)							
		MEAN ROLL ANGLE (SA) (DEGREES)							
		0.5	1.0	2.5	5.0	10.0	15.0	25.0	40.0
0.	0.000018	0.000036	0.000090	0.000180	0.000361	0.000541	0.000902	0.001443	
10.	0.024595	0.024599	0.024612	0.024632	0.024674	0.024715	0.024799	0.024923	
20.	0.048702	0.048703	0.048706	0.048712	0.048724	0.048736	0.048759	0.048795	
30.	0.111119	0.111120	0.111122	0.111125	0.111133	0.111140	0.111154	0.111176	

## ROLL DECAY COEFFICIENTS GROUPED BY DAMPING TYPES

WAVEMAKING = 0.004498

## SKIN FRICTION

SHIP SPEED (KNOTS)	MEAN ROLL ANGLE (SA) (DEGREES)						
	0.5	1.0	2.5	5.0	10.0	15.0	25.0
0.	0.000194	0.000194	0.000194	0.000194	0.000446	0.000602	0.000804
10.	0.000249	0.000249	0.000249	0.000249	0.000567	0.000769	0.001025
20.	0.000304	0.000304	0.000304	0.000304	0.000689	0.000932	0.001242
30.	0.000365	0.000365	0.000365	0.000366	0.000826	0.001118	0.001489

## EDDYMAKING (EXCLUDING BILGEKEELS)

(HULL, SKEG, RUDDER, BRACKET, AND FIN)

SHIP SPEED (KNOTS)	MEAN ROLL ANGLE (SA) (DEGREES)						
	0.5	1.0	2.5	5.0	10.0	15.0	25.0
0.	0.000579	0.001159	0.002897	0.005795	0.012468	0.019474	0.035149
10.	0.000137	0.000274	0.000685	0.001371	0.002951	0.004609	0.008319
20.	0.000042	0.000085	0.000212	0.000424	0.000913	0.001426	0.002579
30.	0.000020	0.000040	0.000099	0.000198	0.000427	0.000666	0.001203

## BILGEKEEL EDDYMAKING

MEAN ROLL ANGLE (SA) (DEGREES)						
0.5	1.0	2.5	5.0	10.0	15.0	25.0
0.011	0.015	0.023	0.032	0.044	0.053	0.067
						0.083

## LIFT

SHIP SPEED (KNOTS)	LIFT					FIN	TOTAL
	HULL	SKEG	RUDDER	BRACKET	BILGKL		
0.	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10.	0.000000	0.010538	0.000000	0.008462	0.001902	0.024591	0.045493
20.	0.000000	0.020674	0.000000	0.016788	0.003778	0.048700	0.089940
30.	0.000000	0.033686	0.000000	0.029063	0.005840	0.111118	0.179708

# SMPIRGW Input File

```

# SMP Irregular Wave Input File
# Record Set 1 - Title
#DDG79R2V.inp - Full - NAVSEA Offsets Draft = 6.60m Trim = 0.30m GM = 1.26m
DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m
# Record Set 2 - Run Options
0 0 1 1 1 1 1 1
# Record Set 3 - Roll Iteration Statistic
2.0000Significant SA
# Record Set 4 - Seaway Description
0 0.0000
# Record Set 4b - Number of Wave Heights
1
# Record Set 4c - Significant Wave Heights
4.0000
# Record Set 4d - Number of Modal Periods
3
# Record Set 4e - Modal Periods
9.0000 11.0000 13.0000
# Record Set 5 - Number of Motion Points
2
# Record Set 5b - Motion Point Locations
1 PILOT HOUSE 5.5200 5.0000 21.5400
2 HELICOPTER SPOT 18.9000 7.6700 10.8200
# 2 UNDERWAY REPLENISHMENT 9.7700 10.1200 12.6500
# Record Set 6 - Number of Relative Motion Points
2
# Record Set 6b - Relative Motion Point Locations
# 1 BOW WETNESS 0.0000 4.5300 15.8700
1 KEEL SLAM 3.0000 0.0000 0.1100
2 HELICOPTER LAND SPOT 18.9000 7.6700 10.8200
# 3 UNDERWAY REPLENISHMENT 9.7700 10.1200 12.6500
# Record Set 7 - Ship Responses
# DSP VEL ACC
11 0 0
# Record Set 7b - Motion Point Responses
# DSP VEL ACC HFE MSI SLD TIP
11 0 11 11 11 11 11
11 0 11 11 11 11 11
# 11 11 11 11 11 0 11
# Record Set 7c - Motion Point Slide/Tip Data
0.9100 0.4000 4.0000 0.1650 0.2330 0.1200 0.0000
# Record Set 7d - Relative Motion Responses
# DSP VEL SLM EMG WET SPR SFR
# 0 0 0 0 11 0 0
0 11 11 0 0 11 0
0 0 0 0 11 0 0
# 0 0 0 0 11 0 0
# Record Set 7d - Slam pressure, Slam Force Data
1 0.3100 0.0000 0.0100 6.4900 8.0000
3.0000 10 0
3.0000 0.00 0.31 0.53 0.96 1.36 1.73 2.08 2.42 2.75 3.07
3.0000 0.11 0.11 0.26 0.64 1.05 1.49 1.95 2.41 2.88 3.36
# Record Set 7e - Load Responses
# HSF VSF TRM HBM VBM
0 0 0 0 0
# Record Set 8 - Stop
STOP

```

# **SMPIRGW Output File Excerpts**

SMP95 - IRREGULAR SEA MODULE

NSWC/CD - DTMB

SEAKEEPING DEPARTMENT CODE 55

DATE = 13-DEC-05

TIME = 10:31:01

I N P U T C A R D S

LINE	1	2	3	4	5	6	7	8
	1234567890123456789012345678901234567890123456789012345678901234567890							

1	# SMP Irregular Wave Input File							
2	# Record Set 1 - Title							
3	#DDG79R2V.inp - Full - NAVSEA Offsets Draft = 6.60m Trim = 0.30m GM = 1.26m							
4	DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m							
5	# Record Set 2 - Run Options							
6	0 0 1 1 1 1 1 1							
7	# Record Set 3 - Roll Iteration Statistic							
8	2.0000Significant SA							
9	# Record Set 4 - Seaway Description							
10	0 0.0000							
11	# Record Set 4b - Number of Wave Heights							
12	1							
13	# Record Set 4c - Significant Wave Heights							
14	4.0000							
15	# Record Set 4d - Number of Modal Periods							
16	3							
17	# Record Set 4e - Modal Periods							
18	9.0000 11.0000 13.0000							
19	# Record Set 5 - Number of Motion Points							
20	2							
21	# Record Set 5b - Motion Point Locations							
22	1 PILOT HOUSE							
23	2 HELICOPTER SPOT							
24	# 2 UNDERWAY REPLENISHMENT							

25	#	Record Set	6	-	Number of Relative Motion Points				
26	2								
27	#	Record Set	6b	-	Relative Motion Point Locations				
28	#	1	BOW WETNESS			0.0000	4.5300	15.870	
29	1	KEEL SLAM				3.0000	0.0000	0.1100	
30	2	HELICOPTER LAND SPOT				18.9000	7.6700	10.8200	
31	3	UNDERWAY REPLENISHMENT				9.7700	10.1200	12.650	
32	#	Record Set	7	-	Ship Responses				
33	#	DSP VEL	ACC						
34	11	0	0						
35	#	Record Set	7b	-	Motion Point Responses				
36	#	DSP VEL	ACC	HFE	MSI	SLD	TIP		
37	11	0	11	11	11	11	11		
38	11	0	11	11	11	11	11		
39	11	11	11	11	11	0	11		
40	#	Record Set	7c	-	Motion Point Slide/Tip Data				
41	0.9100	0.4000	4.0000	0.1650	0.2330	0.1200	0.0000		
42	#	Record Set	7d	-	Relative Motion Responses				
43	#	DSP VEL	SLM	EMG	WET	SPR	SFR		
44	0	0	0	0	11	0	0		
45	0	11	11	0	0	11	0		
46	0	0	0	0	11	0	0		
47	0	0	0	0	11	0	0		
48	#	Record Set	7d	-	Slam pressure, Slam Force Data				
49	1	0.3100	0.0000	0.0100	6.4900	8.0000			
50	3.0000	10	0						

I N P U T C A R D S									
LINE	1	2	3	4	5	6	7	8	
1234567890123456789012345678901234567890123456789012345678901234567890									
51	3.0000	0.00	0.31	0.53	0.96	1.36	1.73	2.08	2.42
52	3.0000	0.11	0.11	0.26	0.64	1.05	1.49	1.95	2.41
53	#	Record Set	7e	-	Load Responses				
54	#	HSF	VSF	TRM	HBM	VBM			
55	0	0	0	0	0				
56	#	Record Set	8	-	Stop				
57	STOP								

# LIMITS ON ARRAY INPUTS - IRREGULAR WAVE MODULE

Input	Variable Name	Limit Name	Limit	Record Set
Significant waveheight	NSIGWH	mxnsigwh	20	9
Locations for motions at a point	NPTLOC	MXNPTLOC	10	5
Locations for relative motion / slamming	NFREBD	MXNFREBD	12	5
Modal periods	NTMOD	MXNTMOD	15	5

(Note: An array limit can be changed by changing the corresponding parameter <limit name> in the file PARAM.DEF and recompiling.)

## Record Set 1 - TITLE

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

## Record Set 2 - OPTIONS

RAO	LRAO	RSV	VLAC	SEV	LC	SC	TOE
0	0	1	1	1	1	1	1

## Record Set 3 - STATISTIC USED FOR ROLL ITERATION

STATISTIC (SA)	STATISTIC NAME
2.0000	Significant SA

## Record Set 4 - SEAWAY DESCRIPTION

SEA TYPE	GAMMA
0	0.0000

## NUMBER OF SIGNIFICANT WAVE HEIGHTS 1

SIGNIFICANT WAVE HEIGHTS  
4.0000

## NUMBER OF MODAL WAVE PERIODS 3

MODAL WAVE PERIODS  
9.0000 11.0000 13.0000  
DATA SET 5 - MOTIONS AT A POINT



NPTLOC

2

NUMBER	NAME	XPTLOC	YPTLOC	ZPTLOC
1	PILOT HOUSE	5.5200	5.0000	21.5400
2	HELICOPTER SPOT	18.9000	7.6700	10.8200

Record Set 6 - RELATIVE MOTION

NFREBD

2

NUMBER	NAME	XPTLOC	YPTLOC	ZPTLOC
1	KEEL SLAM	3.0000	0.0000	0.1100
2	HELICOPTER LAND SPOT	18.9000	7.6700	10.8200

Record Set 7a - Origin Responses

DSP VEL ACC  
11 0 0

Record Set 7b - Responses at Point Locations specified in Record Set 5

PT#	DSP	VEL	ACC	HFE	MSI	SLD	TIP
1	11	0	11	11	11	11	11
2	11	0	11	11	11	11	11

Record Set 7c -

OBJCG	FRIC	XMU	MSI	TIME	LONG	TIP	LAT	TIP	TRIM	ANGLE	HEEL
0.9100	0.4000	4.0000	0.1650	0.0000	0.2330	0.1200	0.0000				

Record Set 7d - Responses at Relative Motion Point Locations Specified in Record Set 6

PT#	DSP	VEL	SLM	EMG	WET	SPR	SFR
1	0	11	11	0	0	11	0
2	0	0	0	0	11	0	0

Slam Pressure/Force Input

K	HWB	DRANGL	ALPHA	SDRAFT	HRS
1	0.31000	0.00000	0.01000	6.49000	8.00000

1/2 WIDTH OF FLAT BOTTOM = 0.310 DEADRISE ANGLE = 0.00  
 EXCEEDANCE = 0.010 DESIGN (OR STATION) DRAFT = 6.490 HOURS OF SHIP OPERATION = 8.00

INPUT OFFSETS FOR OCHI-MOTTER METHOD

STATION	OFFSET	Y	Z	0.00	0.11	0.31	0.53	0.96	1.36	1.73	2.08	2.42	2.75	3.07
3.0000		10		0.00	0.11	0.31	0.53	0.96	1.36	1.73	2.08	2.42	2.75	3.07
3.0000		10	Z =	0.11	0.31	0.53	0.96	1.36	1.73	2.08	2.42	2.75	3.07	3.36

INTERPOLATED OFFSETS FOR OCHI-MOTTER METHOD

Y	1.08	1.02	0.95	0.88	0.80	0.73	0.66	0.58	0.51	0.43	0.31
Z	0.65	0.58	0.52	0.45	0.39	0.32	0.26	0.19	0.13	0.06	0.00

Record Set 7e - Load Responses at load stations specified in the SMPREGW input file  
 HFS VSF TRM HBM VBM  
 0 0 0 0 0 0

Record Set 8 - STOP

STOP  
 SMPIRGW audit trail

13-DEC-05 10:31:01

SMPREGW audit trail

21-NOV-05 17:31:47

from ORGFIL nagcgain = 8  
 Initirg: SWH,PER,TMODAL = 4.00 9.70 9.00

ROLL ANGLE  
(DEG)

**C-30**

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m  
LONGCRESTED - BRETSCHNEIDER  
SIGNIFICANT WAVE HEIGHT = 4.00 METERS

		PITCH ANGLE		(DEG)														
		Significant SA		VALUE / ENCOUNTERED MODAL PERIOD (TOE)														
		SHIP HEADING ANGLE IN DEGREES																
		STBD BEAM																
		90 105 120 135 150 165 180																
V	T0	HEAD	0	15	30	45	60	75	90	105	120	135	150	165	FOLLOW			
0.0	9.0	0.60/12	0.62/12	0.68/12	0.81/11	1.06/11	1.45/10	1.87/10	1.82/10	1.43/10	1.08/11	0.85/11	0.74/11	0.70/12				
	11.0	1.23/14	1.27/14	1.38/13	1.59/13	1.90/13	2.27/13	2.59/13	2.57/13	2.28/13	1.96/13	1.71/13	1.56/13	1.51/13				
	13.0	2.06/15	2.11/15	2.24/15	2.46/15	2.75/15	3.07/15	3.31/14	3.31/14	3.11/15	2.85/15	2.62/15	2.48/15	2.43/15				
10.0	9.0	0.42/10	0.43/10	0.48/10	0.61/10	0.85/10	1.29/10	1.84/10	1.97/11	1.70/12	1.37/14	1.13/15	1.00/16	0.96/16				
	11.0	0.89/11	0.92/11	1.04/11	1.26/12	1.60/12	2.08/12	2.57/13	2.78/13	2.67/14	2.42/15	2.19/16	2.03/17	1.98/17				
	13.0	1.61/13	1.65/13	1.80/13	2.06/13	2.42/13	2.88/14	3.32/15	3.56/15	3.54/16	3.37/17	3.18/18	3.04/18	2.98/18				
20.0	9.0	0.38/ 4	0.39/ 4	0.38/ 8	0.46/ 8	0.68/ 8	1.15/ 9	1.79/10	2.19/12	2.13/15	1.84/19	1.50/23	1.29/26	1.22/27				
	11.0	0.67/10	0.70/10	0.79/10	0.99/10	1.33/10	1.86/11	2.52/13	3.03/14	3.19/17	3.02/19	2.69/23	2.43/26	2.34/27				
	13.0	1.24/11	1.28/12	1.42/11	1.68/12	2.08/13	2.63/13	3.27/15	3.82/16	4.07/18	4.00/20	3.72/23	3.47/26	3.38/27				
30.0	9.0	0.44/ 4	0.44/ 4	0.46/ 4	0.55/ 4	0.68/ 4	0.99/ 9	1.64/10	2.33/13	2.70/20	2.36/30	1.91/45	1.67/70	1.59/99				
	11.0	0.57/ 8	0.59/ 8	0.65/ 9	0.82/ 9	1.09/10	1.57/11	2.31/13	3.16/15	3.81/20	3.70/29	3.25/37	2.97/45	2.88/52				
	13.0	0.94/10	0.98/10	1.09/10	1.32/11	1.69/12	2.25/13	3.03/15	3.94/17	4.69/20	4.77/29	4.42/35	4.16/39	4.07/42				

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m  
LONGCRESTED - BRETSCHNEIDER  
SIGNIFICANT WAVE HEIGHT = 4.00 METERS

HELICOPTER SPOT

XFP = 18.90 YCL = 0.00 ZBL = 10.82

LONGIT. FORCE EST. (G X 100)

Significant SA VALUE / ENCOUNTERED MODAL PERIOD (TOE)

V	T0	HEAD	SHIP HEADING ANGLE IN DEGREES													FOLLOW
			STBD BEAM													
		0	15	30	45	60	75	90	105	120	135	150	165	180		
0.0	9.0	2.19/11	2.29/11	2.61/11	3.15/10	3.83/10	4.24/10	3.58/10	2.31/11	1.53/11	1.23/12	1.14/ 9	1.11/ 9	1.10/ 9		
	11.0	3.99/13	4.09/13	4.41/13	4.89/13	5.38/12	5.54/12	4.91/13	3.80/13	2.86/13	2.25/14	1.90/14	1.74/14	1.69/14		
	13.0	5.75/15	5.84/15	6.10/14	6.47/14	6.79/14	6.82/14	6.26/14	5.34/15	4.45/15	3.76/15	3.29/16	3.03/16	2.95/16		
10.0	9.0	1.98/ 8	2.05/ 8	2.32/ 9	2.77/ 8	3.37/ 9	3.80/ 9	3.53/10	2.57/11	1.84/13	1.43/15	1.25/16	1.19/13	1.18/14		
	11.0	3.44/10	3.53/10	3.81/10	4.25/10	4.76/11	5.09/11	4.89/13	4.20/14	3.51/15	2.96/16	2.57/17	2.35/17	2.29/18		
	13.0	4.97/12	5.05/12	5.31/12	5.69/13	6.11/13	6.38/14	6.27/14	5.80/16	5.24/17	4.70/17	4.27/18	4.00/19	3.91/19		
20.0	9.0	2.00/ 7	2.05/ 7	2.09/ 7	2.37/ 7	2.82/ 8	3.43/ 8	3.45/10	2.96/13	2.53/15	2.19/19	1.84/23	1.62/26	1.53/27		
	11.0	3.02/ 8	3.09/ 8	3.26/ 9	3.62/ 9	4.10/10	4.61/11	4.78/13	4.65/15	4.43/17	4.07/20	3.61/23	3.27/26	3.15/27		
	13.0	4.23/10	4.31/10	4.52/11	4.89/11	5.36/12	5.85/13	6.16/15	6.26/16	6.19/18	5.89/21	5.44/23	5.08/26	4.95/27		
30.0	9.0	1.78/ 4	1.77/ 4	1.89/ 4	2.24/ 4	2.66/ 4	3.16/ 8	3.31/10	3.34/13	3.57/20	3.47/29	3.13/45	2.79/70	2.66/99		
	11.0	2.47/ 7	2.51/ 7	2.68/ 8	3.05/ 8	3.51/ 9	4.06/10	4.49/13	4.94/15	5.52/20	5.53/29	5.26/37	4.94/48	4.80/52		
	13.0	3.41/ 9	3.47/ 9	3.67/10	4.03/10	4.52/11	5.11/13	5.73/15	6.46/17	7.21/20	7.33/29	7.12/35	6.86/39	6.74/42		

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m  
 LONGCRESTED - BRETSCHNEIDER  
 SIGNIFICANT WAVE HEIGHT = 4.00 METERS

HELICOPTER SPOT XFP = 18.90 YCL = 0.00 ZBL = 10.82

LATERAL FORCE EST. (G X 100)

Significant SA VALUE / ENCOUNTERED MODAL PERIOD (TOE)

V	T0	HEAD	SHIP HEADING ANGLE IN DEGREES													FOLLOW
			STBD BEAM													
		0	15	30	45	60	75	90	105	120	135	150	165	180		
0.0	9.0	0.00/99	5.94/12	10.90/12	15.67/12	19.79/12	20.65/12	16.73/12	20.83/12	19.52/12	15.51/12	10.80/12	5.86/12	0.00/99		
	11.0	0.00/99	9.58/12	16.23/12	21.64/12	25.15/12	25.54/12	24.23/12	27.28/12	26.82/12	22.90/12	16.97/12	9.87/12	0.00/99		
	13.0	0.00/99	10.51/13	17.50/13	22.85/13	26.07/13	26.63/13	26.33/13	28.66/13	28.31/13	24.60/13	18.58/13	10.96/13	0.00/99		
10.0	9.0	0.00/99	2.77/ 8	5.76/ 8	9.80/ 8	14.39/ 7	16.99/10	16.03/12	27.49/12	33.74/12	28.72/13	18.52/12	8.01/13	0.00/99		
	11.0	0.00/99	3.71/12	8.74/12	14.06/12	18.97/12	22.00/12	24.46/13	33.49/12	37.70/13	29.85/13	16.67/12	6.56/13	0.00/99		
	13.0	0.00/99	4.78/12	11.50/12	17.37/12	21.98/13	24.64/12	26.94/13	33.09/13	35.15/13	26.79/13	14.17/14	5.36/13	0.00/99		
20.0	9.0	0.00/99	2.35/ 6	5.06/ 6	8.49/ 6	12.45/ 6	14.60/ 6	13.02/10	33.43/11	33.75/13	6.06/19	3.20/23	1.63/26	0.00/99		
	11.0	0.00/99	3.20/ 7	6.21/ 7	9.81/ 7	13.29/ 7	15.41/11	18.63/12	34.99/12	29.88/14	7.52/19	3.70/23	1.91/26	0.00/99		
	13.0	0.00/99	2.94/ 8	6.51/ 9	10.38/10	13.92/11	16.41/12	20.02/13	31.21/13	24.09/14	6.83/19	3.74/23	2.02/26	0.00/99		
30.0	9.0	0.00/99	2.20/ 5	4.75/ 5	7.98/ 5	11.69/ 5	13.61/ 6	8.62/10	28.60/11	5.78/20	3.10/33	2.15/57	1.15/99	0.00/99		
	11.0	0.00/99	2.78/ 6	5.66/ 6	8.70/ 6	11.24/ 6	11.63/ 6	9.12/11	21.86/12	5.44/20	3.10/29	2.18/45	1.23/63	0.00/99		
	13.0	0.00/99	2.92/ 6	5.57/ 7	8.04/ 7	9.89/ 7	9.89/10	8.42/13	14.46/13	4.76/20	2.89/29	2.03/37	1.17/52	0.00/99		

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

LONGCRESTED - BRETSCHNEIDER

SIGNIFICANT WAVE HEIGHT = 4.00 METERS

HELICOPTER LAND SPOT XFP = 18.90 YCL = 7.67 ZBL = 10.82

RELATIVE MOTION (METERS)

Significant SA VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	T0	HEAD			STBD BEAM										FOLLOW		
		0	15	30	45	60	75	90	105	120	135	150	165	180			
0.0	9.0	2.11/10	2.01/ 9	2.00/ 9	2.13/11	2.61/11	3.35/11	3.49/11	1.98/12	2.34/ 8	2.61/ 9	2.56/10	2.43/10	2.32/10			
	11.0	2.13/10	1.88/10	1.92/12	2.38/12	3.24/12	4.04/12	4.05/12	2.79/12	2.36/13	2.45/10	2.50/10	2.48/10	2.50/11			
	13.0	2.18/16	1.88/16	1.99/16	2.60/12	3.52/12	4.24/12	4.20/12	3.15/12	2.40/13	2.19/13	2.19/10	2.25/11	2.40/12			
10.0	9.0	2.03/ 7	2.01/ 7	2.01/ 7	2.09/ 7	2.42/ 9	3.00/ 9	3.29/10	2.34/12	2.71/13	2.63/12	2.39/12	2.26/13	2.30/13			
	11.0	2.17/ 8	2.14/ 8	2.24/11	2.53/11	3.08/12	3.68/12	3.88/12	3.08/12	2.69/13	2.30/12	2.15/12	2.29/13	2.49/15			
	13.0	2.28/12	2.29/12	2.51/12	2.92/12	3.50/12	3.99/12	4.03/13	3.26/13	2.57/13	1.99/12	1.87/12	2.11/13	2.37/16			
20.0	9.0	2.47/ 4	2.44/ 4	2.38/ 6	2.40/ 6	2.49/ 6	2.87/ 8	3.02/10	2.63/12	2.02/13	2.24/19	2.29/23	2.28/26	2.31/29			
	11.0	2.50/ 6	2.49/ 7	2.44/ 7	2.54/ 9	2.79/10	3.20/10	3.43/12	3.02/13	1.79/13	1.93/19	2.26/23	2.36/26	2.48/27			
	13.0	2.51/ 7	2.49/10	2.55/10	2.77/11	3.10/11	3.45/12	3.53/13	2.98/13	1.72/13	1.80/19	2.07/23	2.20/26	2.36/27			
30.0	9.0	2.62/ 4	2.61/ 4	2.69/ 4	2.87/ 4	3.02/ 4	2.84/ 4	2.61/ 9	2.09/13	1.95/20	2.33/39	2.43/99	2.46/99	2.48/99			
	11.0	2.79/ 6	2.77/ 6	2.80/ 6	2.88/ 6	2.86/ 8	2.76/10	2.67/11	1.96/14	1.74/21	2.26/35	2.51/70	2.67/99	2.77/99			
	13.0	2.76/ 6	2.76/ 6	2.72/ 7	2.75/10	2.80/10	2.79/11	2.71/13	2.01/18	1.86/22	2.25/29	2.46/35	2.64/39	2.76/99			

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

LONGCRESTED - BRETSCHNEIDER

SIGNIFICANT WAVE HEIGHT = 4.00 METERS

ADDED RESISTANCE      NEWTON  
(FORCE / 100000.)

Significant SA      VALUE / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

V	T0	HEAD	STBD BEAM												FOLLOW		
			0	15	30	45	60	75	90	105	120	135	150	165	180		
0.0	9.0	2.22/ 9	2.25/ 8	2.29/ 8	2.21/ 8	1.87/ 7	1.09/ 8	0.00/ 5	-1.55/18	-1.88/22	-2.14/99	-2.33/11	-2.37/11	-2.36/12			
	11.0	1.66/ 9	1.69/13	1.75/12	1.71/12	1.39/10	0.64/ 8	0.00/ 5	-1.18/19	-1.57/22	-1.48/26	-1.44/11	-1.42/12	-1.41/12			
	13.0	1.48/14	1.49/13	1.50/13	1.38/12	0.96/11	0.31/ 8	0.00/ 5	-0.86/19	-1.41/23	-1.35/26	-1.18/11	-1.07/12	-1.03/12			
10.0	9.0	1.11/ 6	1.15/ 6	1.24/ 6	1.32/ 6	1.21/ 8	0.85/ 7	0.00/ 5	-1.67/99	-2.38/99	-3.08/99	-4.03/99	-4.73/99	-4.98/99			
	11.0	0.92/10	0.95/10	1.02/10	1.06/10	0.92/ 9	0.52/ 7	0.00/13	-1.28/27	-1.83/99	-1.96/13	-2.30/15	-2.64/16	-2.77/99			
	13.0	0.82/10	0.84/10	0.86/10	0.80/10	0.60/ 9	0.27/ 8	0.00/13	-1.00/27	-1.64/99	-1.69/13	-1.74/15	-1.82/16	-1.86/17			
20.0	9.0	0.63/ 4	0.68/ 4	0.76/ 4	0.82/ 5	0.78/ 7	0.69/ 7	0.00/10	-1.80/99	-2.39/99	-3.35/99	-3.97/99	-4.21/99	-4.26/99			
	11.0	0.49/ 5	0.53/ 5	0.58/ 8	0.62/ 8	0.59/ 8	0.45/ 7	0.00/13	-1.43/99	-1.97/99	-2.28/99	-2.52/99	-2.66/99	-2.70/99			
	13.0	0.38/ 9	0.40/ 9	0.42/ 9	0.42/ 8	0.38/ 8	0.27/ 7	0.00/13	-1.18/99	-1.89/99	-2.08/99	-2.09/99	-2.08/99	-2.08/99			
30.0	9.0	0.37/ 4	0.38/ 4	0.41/ 4	0.39/ 4	0.35/ 7	0.46/ 6	0.00/10	-1.66/99	-2.28/99	-2.57/99	-2.65/99	-2.54/99	-2.48/99			
	11.0	0.16/ 4	0.17/ 4	0.19/ 4	0.22/ 4	0.29/ 7	0.37/ 7	0.00/12	-1.44/99	-2.11/99	-2.12/99	-2.03/99	-1.92/99	-1.87/99			
	13.0	0.00/ 4	0.01/ 4	0.05/ 4	0.12/ 8	0.22/ 7	0.29/ 7	0.00/14	-1.30/99	-2.16/99	-2.21/99	-2.01/99	-1.81/99	-1.73/99			



DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

LONGCRESTED - BRETSCHNEIDER

SIGNIFICANT WAVE HEIGHT = 4.00 METERS

		FIN ANGLE		(DEG)		Significant SA		VALUE / ENCOUNTERED MODAL PERIOD (TOE)		SHIP HEADING ANGLE IN DEGREES		STBD BEAM		FOLLOW	
V	TO	HEAD	0	15	30	45	60	75	90	105	120	135	150	165	180
0.0	9.0	0.00/99	7.87/12	7.67/12	7.45/12	7.11/12	6.76/12	6.61/12	6.81/12	7.31/12	7.60/12	7.79/12	7.99/12	8.00/99	
	11.0	0.00/99	8.65/12	8.46/12	8.25/12	7.97/12	7.79/12	7.76/12	7.77/12	8.10/12	8.36/12	8.55/12	8.72/12	8.00/99	
	13.0	0.00/99	8.91/13	8.78/13	8.61/13	8.40/13	8.30/13	8.30/13	8.26/13	8.49/13	8.69/13	8.84/13	8.96/13	8.00/99	
10.0	9.0	0.00/99	0.83/ 8	5.51/ 8	5.69/ 8	5.81/ 8	6.04/10	6.59/11	7.60/12	8.64/12	9.06/13	9.23/12	9.84/13	0.00/99	
	11.0	0.00/99	6.58/11	6.93/12	7.07/12	7.17/12	7.48/12	7.92/12	8.42/12	9.07/12	9.37/13	9.57/12	10.24/13	0.00/99	
	13.0	0.00/99	7.58/12	7.87/12	7.92/12	7.94/12	8.20/12	8.48/13	8.75/13	9.21/13	9.51/13	9.86/12	10.72/13	0.00/99	
20.0	9.0	0.00/99	0.55/ 7	1.19/ 7	2.04/ 7	4.85/ 7	5.27/ 8	6.23/10	8.41/11	10.31/13	14.31/19	6.70/23	0.34/26	0.00/99	
	11.0	0.00/99	0.92/ 8	5.26/ 8	5.51/ 8	5.87/10	6.53/11	7.43/12	8.95/12	10.59/14	14.33/19	8.29/23	0.38/26	0.00/99	
	13.0	0.00/99	5.40/10	5.98/10	6.36/11	6.81/11	7.45/12	8.09/12	9.03/13	10.81/14	14.44/19	8.60/23	0.39/26	0.00/99	
30.0	9.0	0.00/99	0.35/ 6	0.76/ 6	1.31/ 6	2.02/ 6	4.72/ 7	5.80/ 9	8.79/11	9.04/20	5.14/31	3.03/18	1.55/16	0.00/99	
	11.0	0.00/99	0.57/ 7	1.16/ 7	1.83/ 7	4.88/ 7	5.47/ 9	6.62/10	9.35/12	9.08/20	5.61/29	3.16/39	1.51/16	0.00/99	
	13.0	0.00/99	0.71/ 7	4.60/ 7	5.02/ 8	5.41/ 9	6.02/10	7.00/12	9.29/12	8.27/20	5.46/29	3.16/35	1.50/45	0.00/99	

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

LONGCRESTED - BRETSCHNEIDER

SIGNIFICANT WAVE HEIGHT = 4.00 METERS

		FIN VELOCITY		(DEG/SEC)												
		Significant SA		VALUE / ENCOUNTERED MODAL PERIOD (TOE)												
		SHIP HEADING ANGLE IN DEGREES														
		STBD BEAM										FOLLOW				
V	T0	HEAD	0	15	30	45	60	75	90	105	120	135	150	165	180	
0.0	9.0	0.00/99	4.66/12	4.66/12	4.66/12	4.66/11	4.66/11	4.66/11	4.66/11	4.66/11	4.66/11	4.66/11	4.66/12	4.66/12	0.00/99	
	11.0	0.00/99	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	0.00/99	
	13.0	0.00/99	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	4.66/12	0.00/99	
10.0	9.0	0.00/99	0.70/ 8	4.66/ 8	4.66/ 8	4.66/ 8	4.66/ 8	4.66/ 8	4.68/10	4.75/11	4.78/12	4.69/13	4.68/12	4.67/13	0.00/99	
	11.0	0.00/99	4.66/10	4.66/10	4.66/10	4.66/11	4.66/12	4.68/12	4.73/12	4.78/12	4.80/12	4.68/13	4.67/12	4.67/13	0.00/99	
	13.0	0.00/99	4.66/12	4.66/12	4.66/12	4.67/12	4.66/12	4.70/12	4.72/13	4.77/12	4.76/12	4.67/13	4.66/12	4.66/13	0.00/99	
20.0	9.0	0.00/99	0.59/ 6	1.25/ 6	2.04/ 6	4.67/ 7	4.67/ 7	4.67/ 7	4.66/ 9	4.93/10	4.66/13	4.66/19	2.06/23	0.15/26	0.00/99	
	11.0	0.00/99	0.79/ 7	4.67/ 7	4.66/ 7	4.66/ 7	4.67/ 8	4.67/10	4.66/11	4.94/12	4.70/14	4.69/19	2.33/23	0.12/26	0.00/99	
	13.0	0.00/99	4.67/ 8	4.67/ 8	4.66/ 9	4.66/ 9	4.68/10	4.69/11	4.68/12	4.82/12	4.72/14	4.66/19	2.36/23	0.11/26	0.00/99	
30.0	9.0	0.00/99	0.46/ 6	0.94/ 6	1.53/ 6	2.19/ 6	4.67/ 7	4.67/ 7	4.69/ 8	4.72/11	2.73/20	1.45/30	1.29/15	0.78/13	0.00/99	
	11.0	0.00/99	0.59/ 6	1.17/ 6	1.78/ 6	4.68/ 7	4.68/ 7	4.66/ 7	4.70/10	4.83/11	2.78/20	1.32/29	0.96/15	0.57/13	0.00/99	
	13.0	0.00/99	0.65/ 7	4.67/ 7	4.69/ 7	4.69/ 7	4.69/ 7	4.68/ 9	4.67/10	4.67/11	2.53/20	1.22/29	0.77/35	0.43/13	0.00/99	

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

LONGCRESTED - BRETSCHNEIDER

SIGNIFICANT WAVE HEIGHT = 4.00 METERS

PILOT HOUSE

XFP = 5.52 YCL = 5.00 ZBL = 21.54

MOTION SICKNESS PCT- 4.0 HR / MODAL PERIOD TOE

V TO	HEAD	SHIP HEADING ANGLE IN DEGREES										FOLLOW		
		STBD BEAM												
		0	15	30	45	60	75	90	105	120	135	150	165	180
0.0	9.0	0./ 11	0./ 10	0./ 10	1./ 10	4./ 9	10./ 8	10./ 8	3./ 10	0./ 12	0./ 12	0./ 12	0./ 12	0./ 11
	11.0	1./ 13	0./ 13	0./ 13	1./ 13	1./ 13	3./ 13	3./ 13	3./ 13	2./ 13	1./ 13	1./ 13	0./ 13	0./ 13
	13.0	1./ 14	1./ 14	1./ 14	1./ 14	2./ 14	3./ 13	4./ 13	3./ 13	3./ 13	2./ 13	1./ 13	1./ 13	0./ 14
10.0	9.0	3./ 8	2./ 8	3./ 8	5./ 8	8./ 8	14./ 8	12./ 8	1./ 12	1./ 13	1./ 13	0./ 14	0./ 13	0./ 16
	11.0	4./ 10	4./ 10	4./ 10	5./ 10	8./ 10	11./ 9	4./ 13	2./ 13	2./ 13	1./ 13	0./ 15	0./ 17	0./ 17
	13.0	4./ 11	4./ 11	5./ 10	5./ 10	3./ 13	4./ 13	4./ 13	3./ 13	3./ 13	1./ 15	0./ 17	0./ 17	0./ 18
20.0	9.0	3./ 4	4./ 4	7./ 7	8./ 7	12./ 7	18./ 7	12./ 9	2./ 12	1./ 14	0./ 19	0./ 23	0./ 26	0./ 27
	11.0	10./ 8	10./ 8	10./ 8	11./ 8	13./ 8	14./ 9	7./ 11	2./ 13	1./ 15	0./ 19	0./ 23	0./ 26	0./ 27
	13.0	11./ 9	10./ 9	10./ 9	10./ 10	11./ 10	7./ 12	4./ 13	2./ 14	0./ 17	0./ 19	0./ 23	0./ 26	0./ 27
30.0	9.0	7./ 4	6./ 4	7./ 4	10./ 4	14./ 4	22./ 7	13./ 9	1./ 13	0./ 20	0./ 29	0./ 39	0./ 4	0./ 4
	11.0	15./ 7	15./ 7	16./ 7	18./ 7	20./ 7	18./ 8	8./ 11	1./ 14	0./ 20	0./ 29	0./ 35	0./ 42	0./ 45
	13.0	18./ 7	17./ 8	18./ 8	17./ 8	17./ 9	12./ 10	5./ 13	1./ 15	0./ 20	0./ 29	0./ 35	0./ 39	0./ 42

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

LONGCRESTED - BRETSCHNEIDER  
SIGNIFICANT WAVE HEIGHT = 4.00 METERS

PILOT HOUSE XFP = 5.52 YCL = 5.00 ZBL = 21.54

SLIDING MOTION INTERRUPTIONS PER MINUTE

V	T0	HEAD	SHIP HEADING ANGLE IN DEGREES												FOLLOW
			STBD BEAM												
		0	15	30	45	60	75	90	105	120	135	150	165	180	
0.0	9.0	0.0	0.9	2.4	3.5	4.2	4.5	4.9	4.7	4.1	3.4	2.4	0.9	0.0	
	11.0	0.0	2.0	3.4	4.2	4.6	4.7	4.9	4.8	4.6	4.2	3.5	2.1	0.0	
	13.0	0.0	2.2	3.5	4.2	4.6	4.7	4.7	4.7	4.6	4.3	3.6	2.4	0.0	
10.0	9.0	0.0	0.1	0.9	1.8	3.1	3.9	4.8	5.0	4.9	4.5	3.6	1.5	0.0	
	11.0	0.0	0.2	1.5	3.0	4.0	4.4	4.9	5.0	5.0	4.5	3.3	1.0	0.0	
	13.0	0.0	0.5	2.3	3.6	4.2	4.5	4.7	4.9	4.8	4.2	2.8	1.1	0.0	
20.0	9.0	0.0	0.1	0.5	1.0	2.1	3.1	4.5	5.1	4.4	0.3	0.1	0.0	0.0	
	11.0	0.0	0.2	0.6	1.5	2.7	3.5	4.5	5.0	4.1	0.8	0.1	0.0	0.0	
	13.0	0.0	0.0	0.7	1.8	3.0	3.6	4.3	4.7	3.7	0.6	0.0	0.0	0.0	
30.0	9.0	0.0	0.0	0.2	0.7	1.7	1.9	3.5	4.4	0.1	0.0	0.0	0.0	0.0	
	11.0	0.0	0.2	0.4	1.1	1.6	1.9	3.0	3.7	0.0	0.0	0.0	0.0	0.0	
	13.0	0.0	0.2	0.0	0.3	1.4	2.2	2.3	3.0	0.0	0.0	0.0	0.0	0.0	

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

LONGCRESTED - BRETSCHNEIDER

SIGNIFICANT WAVE HEIGHT = 4.00 METERS

PILOT HOUSE

XFP = 5.52 YCL = 5.00 ZBL = 21.54

TIPPING MOTION INTERRUPTIONS PER MINUTE

SHIP HEADING ANGLE IN DEGREES

V TO	HEAD				STBD BEAM								FOLLOW		
	0	15	30	45	60	75	90	105	120	135	150	165	180		
0.0	9.0	0.3	3.6	5.1	5.8	6.3	6.5	7.0	6.7	6.2	5.7	5.0	3.6	0.1	
	11.0	0.6	4.5	6.0	6.2	6.2	6.3	6.5	6.4	6.2	5.9	5.5	4.6	0.3	
	13.0	0.8	4.7	5.9	6.1	6.2	6.2	6.3	6.2	6.1	5.9	5.5	4.8	0.5	
10.0	9.0	0.9	1.5	5.1	6.1	6.1	6.5	6.9	6.5	6.3	5.9	5.5	3.9	0.0	
	11.0	1.3	1.6	5.6	6.1	6.1	6.3	6.5	6.4	6.2	5.9	5.2	3.5	0.1	
	13.0	1.6	2.3	5.7	6.1	6.2	6.2	6.3	6.2	6.1	5.7	4.9	3.0	0.2	
20.0	9.0	2.0	1.8	4.7	5.7	6.3	6.3	7.0	6.5	5.7	1.6	0.7	0.5	0.0	
	11.0	2.3	1.9	4.9	5.8	6.1	6.1	6.5	6.3	5.5	2.4	0.8	0.7	0.0	
	13.0	2.5	0.9	4.9	5.7	5.9	6.1	6.1	6.1	5.2	2.0	0.8	0.8	0.0	
30.0	9.0	2.4	2.0	3.5	4.9	5.7	5.7	6.6	6.0	0.8	0.7	0.4	0.0	0.0	
	11.0	3.1	2.1	3.9	4.5	5.3	5.3	6.0	5.5	0.5	0.5	0.4	0.1	0.0	
	13.0	3.2	1.8	2.3	4.1	4.8	4.8	5.3	4.7	0.3	0.3	0.3	0.1	0.0	

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

C-40

LONGCRESTED - BRETSCHNEIDER

SIGNIFICANT WAVE HEIGHT = 6.00 METERS

KEEL SLAM

XFP = 3.00 YCL = 0.00 ZBL = 0.11

SLAMMING

THRESHOLD VELOCITY = 3.48 METERS/SEC

PROBABILITYX100 / NO. OF OCCURRENCES PER HOUR

V	T0	SHIP HEADING ANGLE IN DEGREES													FOLLOW												
		STBD BEAM																									
		0	15	30	45	60	75	90	105	120	135	150	165	180													
0.0	9.0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.3/	1	0.1/	0	0.0/	0	0.0/	0	0.0/	0						
	11.0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.3/	1	1.2/	4	1.5/	5	0.8/	3	0.4/	1	0.2/	0	0.1/	0	0.1/	0		
	13.0	0.0/	0	0.0/	0	0.0/	0	0.1/	0	0.5/	1	1.6/	4	3.3/	10	3.7/	11	2.6/	7	1.6/	4	1.0/	3	0.8/	2	0.7/	2
10.0	9.0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.3/	1	0.3/	1	0.1/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0
	11.0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.1/	0	0.4/	1	1.5/	5	0.9/	2	0.2/	0	0.1/	0	0.0/	0	0.0/	0	0.0/	0
	13.0	0.0/	0	0.0/	0	0.1/	0	0.2/	0	0.7/	2	2.1/	6	4.1/	12	4.4/	12	2.9/	7	1.3/	3	0.5/	1	0.3/	0	0.2/	0
20.0	9.0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.2/	0	0.3/	1	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0
	11.0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.3/	1	1.4/	4	1.8/	5	0.6/	1	0.0/	0	0.0/	0	0.0/	0	0.0/	0
	13.0	0.0/	0	0.0/	0	0.1/	0	0.2/	0	0.6/	2	1.8/	6	3.8/	11	4.5/	11	2.4/	5	0.5/	0	0.0/	0	0.0/	0	0.0/	0
30.0	9.0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.1/	0	0.2/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.1/	0	0.1/	0
	11.0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.0/	0	0.2/	0	1.0/	3	1.5/	3	0.4/	0	0.0/	0	0.0/	0	0.0/	0	0.1/	0
	13.0	0.0/	0	0.0/	0	0.0/	0	0.1/	0	0.3/	1	1.1/	4	2.8/	8	3.8/	8	1.8/	3	0.1/	0	0.0/	0	0.0/	0	0.0/	0

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

LONGCRESTED - BRETSCHNEIDER

SIGNIFICANT WAVE HEIGHT = 6.00 METERS

KEEL SLAM

XFP = 3.00 YCL = 0.00 ZBL = 0.11

SLAMMING

THRESHOLD VELOCITY = 4.32 METERS/SEC

EXTREME PRESSURE IN KPA / NO. SLAMS PER HOUR

SLAM STATION FORM FACTOR = 10.73

RDOT BASED ON FORM FACTOR = 4.32

SHIP HEADING ANGLE IN DEGREES

V	T0	HEAD	STBD BEAM												FOLLOW		
			0	15	30	45	60	75	90	105	120	135	150	165	180		
0.0	9.0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0 287./	0 333./	1 266./	0 0./	0 0./	0 0./	0 0./	0	0
	11.0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0 247./	1 359./	4 386./	5 327./	3 271./	1 232./	0 0./	0 0./	0 0./	0	0
	13.0	0./ 0	0./ 0	0./ 0	0./ 0	0 235./	1 323./	4 413./	10 431./	11 382./	7 329./	4 289./	3 266./	2 259./	2		
10.0	9.0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0 311./	1 288./	1 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0	0
	11.0	0./ 0	0./ 0	0./ 0	0./ 0	0 304./	1 389./	5 369./	5 269./	2 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0	0
	13.0	0./ 0	0./ 0	0 252./	0 304./	2 379./	6 449./	12 430./	12 343./	7 259./	3 200./	1 0./	0 0./	0 0./	0 0./	0	0
20.0	9.0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0 312./	0 246./	1 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0	0
	11.0	0./ 0	0./ 0	0./ 0	0./ 0	0 341./	1 392./	4 342./	5 216./	1 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0	0
	13.0	0./ 0	0./ 0	0 301./	0 323./	0 357./	2 408./	6 454./	11 412./	11 294./	5 0./	0 0./	0 0./	0 0./	0 0./	0	0
30.0	9.0	0./ 0	0./ 0	0./ 0	0./ 0	0./ 0	0 287./	0 204./	0 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0	0
	11.0	0./ 0	0./ 0	0./ 0	0./ 0	0 345./	0 356./	3 296./	3 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0	0
	13.0	0./ 0	0./ 0	0 380./	0 384./	1 394./	4 410./	8 363./	8 240./	3 0./	0 0./	0 0./	0 0./	0 0./	0 0./	0	0

DDG79R2V NSEA Offsets Dr 6.60m GM 1.26m Tr 0.30m

LONGCRESTED - BRETSCHNEIDER  
SIGNIFICANT WAVE HEIGHT = 4.00 METERS

HELICOPTER LAND SPOT XFP = 18.90 YCL = 7.67 ZBL = 10.82  
SUBMERGENCE

PROBABILITYX100 / NO. OF OCCURRENCES PER HOUR

V	TO	HEAD	SHIP HEADING ANGLE IN DEGREES																FOLLOW						
			STBD BEAM																						
		0	15	30	45	60	75	90	105	120	135	150	165	180											
0.0	9.0	0.0/	0	0.0/	0	0.0/	0	0.5/	2	4.2/	18	5.3/	25	0.0/	0	0.1/	0	0.5/	2	0.4/	2	0.2/	1	0.1/	0
	11.0	0.0/	0	0.0/	0	0.2/	0	3.4/	12	11.3/	41	11.5/	44	1.0/	3	0.2/	0	0.3/	1	0.3/	1	0.3/	1	0.3/	1
	13.0	0.1/	0	0.0/	0	0.5/	1	5.7/	18	13.8/	45	13.2/	45	2.7/	8	0.2/	0	0.1/	0	0.1/	0	0.1/	0	0.2/	0
10.0	9.0	0.0/	0	0.0/	0	0.0/	0	0.3/	1	2.3/	12	4.5/	21	0.2/	0	1.0/	3	0.8/	2	0.3/	0	0.1/	0	0.2/	0
	11.0	0.1/	0	0.1/	0	0.5/	2	2.8/	12	8.3/	34	10.7/	41	2.9/	9	0.9/	3	0.2/	0	0.1/	0	0.2/	0	0.4/	1
	13.0	0.1/	0	0.2/	0	0.5/	2	1.9/	7	6.4/	24	12.1/	43	4.2/	12	0.6/	1	0.0/	0	0.0/	0	0.1/	0	0.3/	0
20.0	9.0	1.2/	13	1.0/	11	0.8/	8	0.9/	8	1.3/	10	3.7/	24	5.1/	25	2.0/	6	0.1/	0	0.5/	0	0.6/	1	0.5/	1
	11.0	1.3/	11	1.3/	10	1.0/	8	1.5/	10	3.1/	18	7.0/	35	9.9/	39	5.1/	15	0.0/	0	0.1/	0	0.5/	0	0.8/	1
	13.0	1.3/	9	1.2/	8	1.5/	9	2.9/	16	5.9/	27	10.2/	42	11.4/	39	4.7/	13	0.0/	0	0.0/	0	0.2/	0	0.4/	0
30.0	9.0	21.2/	282	20.9/	273	22.9/	276	27.4/	290	31.0/	284	26.7/	210	20.9/	108	8.7/	25	6.0/	13	14.0/	42	16.5/	67	17.1/	83
	11.0	25.4/	256	25.0/	247	25.7/	240	27.7/	236	27.1/	207	24.8/	157	22.5/	96	6.3/	16	2.9/	5	12.4/	27	18.4/	50	22.3/	69
	13.0	24.6/	205	24.6/	200	23.6/	184	24.5/	176	25.7/	162	25.3/	130	23.3/	85	7.1/	16	4.6/	8	12.1/	22	17.3/	35	21.6/	49



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## RunSMP95 Batch File

```
@echo off
Rem SMP95 Batch File for Windows 95/98, NT4/2000, MSDOS

if "%1"==" " echo Enter runsmp95 filename (for input file, w/o .inp)
if "%1"==" " goto end

if exist %1.inp copy %1.inp regfile.inp
if not exist %1.inp echo RegWave Input File %1.inp does not exist
if not exist %1.inp goto end

dir %1.inp > regfile.idf

if exist %1.out del %1.out
if exist %1.log del %1.log
if exist %1.hpl del %1.hpl
if exist %1.bnt del %1.bnt
if exist %1.ltf del %1.ltf
if exist %1.org del %1.org
if exist %1.ptf del %1.ptf

\SMP95\smpregw.exe

rename regfile.log %1.LOG
rename regfile.out %1.OUT
if exist regfile.hpl rename regfile.hpl %1.hpl
if exist regfile.bnt rename regfile.bnt %1.bnt
if exist regfile.ltf rename regfile.ltf %1.ltf
if exist regfile.org rename regfile.org %1.org
if exist regfile.ptf rename regfile.ptf %1.ptf

del regfile.* >NULL

Echo SMP95 Regular Wave Calculations Complete,
Echo Proceeding to Irregular Wave Calculations

if exist %1.irg copy %1.irg irgfile.irg
if not exist %1.irg echo IrgWave Input File %1.irg does not exist
if not exist %1.irg goto end

if exist %1.org copy %1.org irgfile.org
if not exist %1.org echo Transfer Function File %1.org does not exist
if not exist %1.org goto end

if exist %1.ltf copy %1.ltf irgfile.ltf
if not exist %1.ltf echo Load Transfer Function File %1.ltf does not exist
if exist %1.ptf copy %1.ptf irgfile.ptf
if not exist %1.ptf echo Tank Transfer Function File %1.ptf does not exist

dir %1.irg > irgfile.idf

if exist %1.lgg del %1.lgg
if exist %1.oof del %1.oof
```

```
if exist %1.sev del %1.sev
if exist %1.spd del %1.spd
if exist %1.spl del %1.spl
if exist %1.slm del %1.slm

\SMP95\smpirgw.exe

if exist irgfile.lgg rename irgfile.lgg %1.lgg
if exist irgfile.oot rename irgfile.oot %1.oot
if exist irgfile.sev rename irgfile.sev %1.sev
if exist irgfile.spd rename irgfile.spd %1.spd
if exist irgfile.spl rename irgfile.spl %1.spl
if exist irgfile.slm rename irgfile.slm %1.slm

del irgfile.* >NULL

:end
```

The individual DOS batch files RunREGW.bat and RunIRGW.bat are the first and last halves, respectively, of the RunSMP95.bat file listed above.

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